EFFECT OF SUPPLEMENTAL SELENIUM AND VITAMIN E ON SERUM AND MILK CONCENTRATIONS OF CATTLE AND SHEEP, TISSUE SELENIUM CONCENTRATIONS AND MINERAL STATUS OF GRAZING CATTLE IN NORTH FLORIDA

By

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DEDICATION

To the memory of my mother, María Muñoz, who dedicated many years of her life to show me the values of knowledge, dedication and patience.

To my son Pedro Pablo, whose support, friendship and patience made everything easier and meaningful.

To my sister Georgina, whose constant support, understanding and faith in God made possible the achievement of our goal.

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Abstract of Dissertation Presented to the Graduate School
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EFFECT OF SUPPLEMENTAL SELENIUM AND VITAMIN E ON SERUM AND MILK CONCENTRATIONS OF CATTLE AND SHEEP, TISSUE SELENIUM CONCENTRATIONS AND MINERAL STATUS OF GRAZING CATTLE IN NORTH FLORIDA

By

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Four experiments were conducted in north Florida to evaluate the effect of supplemental selenium (Se) and vitamin E on serum concentrations in beef cattle and sheep and their offspring. Selenium concentrations in liver, milk and hair of cows as well as mineral status of cattle based on forage, soil and animal tissues were also evaluated.

For the first two experiments all soil and forage samples were deficient in Se. Supplemental Se increased serum Se concentrations of cows in experiment 2, but liver and milk Se concentrations were higher than the controls only in October. Similarly, only in October serum Se concentrations of cows and calves were higher than the controls in experiment 1. Selenium treated cows had lower serum vitamin E concentrations in March and June than control cows. Neither Se nor vitamin E had any effect on lymphocyte blastogenic response but the health status of cattle was satisfactory.

In addition to Se, soil samples were low to deficient in K, Zn, P, Cu and Mn, and forage samples were low to deficient in Na, P, Cu, Zn and Co; consequently, grazing cattle required supplementation of these minerals. Except for low serum P in cows, overall mineral status of cattle was adequate in both experiments.

In experiments 3 and 4 there was no effect of prepartum injectable Se on serum Se concentrations of ewes or lambs and serum vitamin E concentrations of cows and ewes. Supplemental Se increased Se concentrations in serum of cows and colostrum of cows and ewes. Brahman cows had higher serum Se and vitamin E concentrations at two months post-partum than crossbred cows. Calves had lower serum Se concentrations at two months than at birth but the lowest serum vitamin E concentrations at birth and the highest at two months, thus indicating inefficient placental transfer of vitamin E.

Concentrations of serum Se were lower for ewes at the pre-treatment sampling but, the highest serum vitamin E concentrations were found at the pre-treatment sampling. Lambs from ewes treated with the highest vitamin E dose (9 mg α-tocopherol/kg) had higher serum vitamin E concentrations than lambs from ewes treated with the low dose.

CHAPTER I
INTRODUCTION

The human population continues to increase rapidly, and at the same time the efficiency of food production from agricultural areas must improve to satisfy the demand and provide better standards and quality of products. Ruminant animals play important roles in utilization of feedstuffs due to their adaptation to extreme environmental, edaphic, and climatic conditions, as well as in the transformation of fibrous resources into nutritious food for the human population. Feeding the required nutrients to the animal is important for maintenance of normal health, optimum metabolic functions and animal productivity.

Selenium is an essential nutrient for livestock. However, its toxicity was first recognized and characterized in livestock grazing on seleniferous areas; subsequently, its deficiency was recognized for animals fed feedstuffs grown in selenium deficient soils. Florida is one of the areas of the United States with low concentrations of selenium in soils and plants; consequently, cattle fed on these pastures do not receive adequate dietary selenium (Koller et al., 1984). Selenium deficiency in livestock provokes several diseases which cause enormous yearly economic losses to producers. These diseases range from the well recognized severe condition 'white muscle disease' to the numerous less explicit conditions referred to as selenium-associated/responsive diseases (Koller and Exon, 1986). Similarly, vitamin E has long been recognized as an essential nutrient for all livestock species. Green forage in vegetative stage contains adequate quantities of vitamin E for most ruminants; however, vitamin E content of forages may decrease significantly as a result of maturity and long term storage. Especially in ensiled forages, vitamin E losses increase with increasing moisture content of the ensiled material.

The functioning immune system requires adequate levels of selenium and vitamin E for optimum performance. Synergism between vitamin E and selenium has been reported to provide tissue protection and prevent nutritional diseases under controlled conditions in several species; however, it is important to evaluate the response of ruminant animals to supplementation with these nutrients under field conditions.

The objectives of this research were to 1) evaluate the effect of supplemental Se and vitamin E on cattle response to disease conditions (diarrhea, pneumonia, shipping fever syndrome and Heinz body anemia), as well as the cattle immune responsivenes through time; 2) evaluate the effect of supplementation of these nutrients on tissue content of cows, ewes and their offspring through time; and 3) evaluate the overall mineral status of grazing cattle on the basis of soil, forage and animal tissue concentrations.

CHAPTER II
LITERATURE REVIEW

Selenium

Selenium (Se) is a trace element near to sulfur in the periodic table of chemical elements and has several chemical properties similar to sulfur. As a result of this similarity, some biological processes utilize Se or sulfur indiscriminately (Ganther, 1974). Most of the commercial Se is a by-product of precious metals recovery from electrolytic refinery slime, which vary in Se composition from .55 % to 2% (Oldfield, 1990). Higher plants vary in their capability to extract soil Se, so that some wild species accumulate very large amounts of the element. These plants are called Se indicators, since they grow on seleniferous soils but they will not grow to maturity where soil Se concentrations are very low. In some areas soil Se is very low, as in volcanic regions; or is not biologically available as a result of acidity and frequent complexing with iron (McDowell et al., 1983; Oldfield, 1990).

Distribution and Function in Animals

Selenium occurs in all cells and tissues of the body in concentrations that vary with the tissue and the amount and chemical form of dietary Se. The greatest Se concentrations occur in liver and kidney, but the largest total amount in the body is found in muscles (Levander, 1986). Blood Se concentration is highly responsive to dietary intake (Perry et al., 1978); thus deficiencies or toxicities of Se can be easily detected in humans and animals. Levander (1986) indicates that in animal tissues Se is partly incorporated into protein as Se analogues of the sulfur containing amino acids, and as the main functioning form of Se, glutathione peroxidase (GSH-px). Combs and Combs (1986) indicated that this selenoprotein contains 4 g atoms of Se per mole and catalyzes the reduction of hydrogen peroxide or lipid peroxides. Its activity has been demonstrated in body tissues, fluids, cells and subcellular fractions.

Selenium is required for growth and fertility in animals and to prevent a variety of disease conditions which may also respond to vitamin E. Among the Se responsive diseases are: exudative diathesis and pancreatic diseases in poultry, nutritional muscular dystrophy (NMD) in lambs, calves and other species, hepatosis dietetica and mulberry heart disease in pigs and unthriftiness in sheep and cattle (Underwood, 1977).

Nutritional muscular dystrophy

Nutritional muscular dystrophy or white muscle disease (WMD) is a degenerative disease of the striate muscle in young ruminants caused by a Se deficiency, but influenced by vitamin E status (McDowell, 1989). It may develop intrauterinely (Hamliri et al., 1990), in lambs up to 12 weeks old (delayed form), and in older sheep up to one year old (Allen et al., 1986). Lambs affected at birth usually die within a few days, but the delayed form is the most common. The disease is characterized by necrosis of the skeletal or cardiac musculature, or both. Biochemically, it is characterized by abnormal levels of serum glutamic oxalacetic transaminase (SGOT) and lactic dehydrogenase (Levander, 1986). However, Brown and Wagner (1968) indicated that creatine kinase (CK) is considered a more sensitive indicator of NMD in lambs due to its predominance in striate muscle. NMD has received most attention in lambs and calves because of its economic importance and natural occurrence, but similar degenerative changes occur in other livestock species. A buckling condition was observed in feeder calves in Florida (McDowell et al., 1985). Animals had weakness of the rear legs, buckling of the fetlocks and finally paralysis.

Selenium responsive unthriftiness

In parts of New Zealand NMD occurs in lambs on pasture and can occur in beef and dairy cattle of all ages (Hartley, 1967; McDonald, 1975). This condition varies from subnormal growth rate to unthriftiness with rapid loss of weight and sometimes mortality. This disease can be prevented by Se but not vitamin E supplementation (Underwood, 1977).

Beef cattle grazing St Augustine grass in the Florida Everglades developed anemia associated with the presence of Heinz bodies and suboptimal blood Se concentrations (Morris et al., 1984). Supplemental Se, as sodium selenate provided in the drinking water corrected anemia, prevented Heinz bodies formation, increased body weight and blood Se levels.

Effects on reproduction

Impaired reproductive performance has been reported due to Se deficiency in most of the animal species studied. High incidence of infertility in ewes in parts of New Zealand has been associated with WMD and unthriftiness (Hartley, 1963). This reproductive problem was improved by Se supplementation of the ewe at mating and one month before lambing. Neither vitamin E nor an antioxidant was effective to counteract this problem (Underwood, 1977).

Response to diseases

Selenium affects the components of the immune system. In general a deficiency of Se appears to result in immunosuppression whereas supplementation with low doses of Se appears to result in augmentation and/or restoration of immunological functions. A deficiency of Se has been shown to reduce resistance to microbial and viral infections, neutrophil function, antibody production, proliferation of T and B lymphocytes in response to mitogens, and cytodestruction by T lymphocytes and neutral killer cells (Kiremidjian-Schumacher and Stotzky, 1987).

Koller and Exon (1986) indicated that many conditions related to Se deficiency in livestock are referred to as Se-associated or Se-responsive diseases. Some of the Se-associated/responsive diseases include muscular weakness of the newborn, reduced gain, diarrhea, stillbirths, abortions, calf scours and pneumonia, retained placenta and diminished fertility. Selenium supplementation enhanced antibody response in weaned beef calves fed a Se-deficient diet (Swecker et al., 1989). Supplemental Se along with vitamin E enhanced serum antibody response to Pasteurella hemolytica in steers new to the feedlot environment (Droke and Loerch, 1989). Sheffy and Schultz (1979) reported impaired mitogenic stimulation of lymphocytes in Se-deficient dogs. Phillips et al. (1989) indicated that Se deficiencies are frequently subclinical, and for this reason, clinical signs are not specific enough to distinguish from other nutritional conditions.

Metabolism

Selenium metabolism is highly dependent on the chemical form and amount of the element that is ingested and in the presence or absence of numerous interacting dietary factors. In addition there are differences between species in metabolism, especially between ruminants and monogastrics.

Absorption

Many factors interfere with absorption of nutrients from the intestinal tract. About 40% of orally administered Se is absorbed by cattle (Harrison and Conrad, 1984a) but the extent of absorption will depend on the form of the element, the amount that is provided and the nature of the rest of the diet. Calcium, arsenic, cobalt and sulfur may decrease the absorption of Se by 50% or more (NRC, 1980; Harrison and Conrad, 1984b), while nitrates may tie up Se and prevent absorption (Smith et al., 1988).

The main site of absorption is the duodenum and there is no absorption from the rumen or abomasum of sheep or stomach of pigs (Wright and Bell, 1966). They also reported net absorption of 85% for pigs and 35% for sheep from rations containing 0.35-0.5 μg Se/g. Lowered absorption by ruminants may be due to reduction of selenite to insoluble forms in the rumen.

Placental and mammary transfer

Transfer of nutrients to offspring occurs via placental transfer and colostrum ingestion. The amount of transferred nutrients will depend upon maternal nutrient status and efficiency of transplacental and mammary transport mechanisms (Van Saun et al., 1989a). Selenium is readily transferred through the placenta to the fetus, even in the presence of low maternal Se concentrations. The fetus can sequester blood Se from the dam and accumulate greater amounts of Se than the dam in the blood (Koller et al., 1984) and in the liver (Van Saun et al., 1989a). Possibly the fetal liver has a higher affinity for Se, clearing more Se from plasma compared to the dam.

Prepartum Se supplementation of the dam has increased serum Se of the calf at birth (Perry et al., 1978; Weiss et al., 1984; Koller et al, 1984; Kincaid and Hodson, 1989). Selenium transport into colostrum and milk occurs primarily through the secretory vesicles associated with casein in the mammary alveolar epithelial cell (Allen and Miller, 1981).

Colostrum Se concentrations are greater than those of milk (Koller et al., 1984; Salih et al., 1987; Stowe et al., 1988; Van Saun et al., 1989a). Prepartum supplementation of Se has increased colostrum Se concentrations (Campbell et al., 1990; Salih et al., 1987; Stowe et al., 1988); however, de Toledo and Perry, (1985) reported no effect of Se supplementation on colostrum Se concentrations.

Several studies have reported little change in the concentrations of Se in milk from diets supplemented with Se. Conrad and Moxon (1979) found that only 4.8% of the Se added as sodium selenite to the diet was transferred to milk of dairy cows whose diet was deficient in Se; however only 0.9% was transferred to milk of cows with Se adequate diets. Maus et al. (1980) reported a significant increase in the content of milk Se from .03 to .06 μg/ml with Se dietary levels of to up to 6 mg/d. Higher milk Se concentrations were obtained by Essick and Lisk (1987), Campbell et al. (1990), and McDowell et al. (1990) in Se supplemented cows.

Excretion

Selenium is excreted by feces, urine and exhalation. Feces is the main route of Se excretion in ruminants and urine in monogastrics (Langlands et al., 1986; Levander, 1986). The quantity of Se excreted in feces increased when sheep had a greater intake of organic matter but not when forage had higher Se content (Langlands et al., 1986)

Metabolic Transactions

Levander (1986) indicated that Se metabolic transformations are complex in nature and depend on the chemical form of Se supplied to the body. Selenate is reduced to selenite which in turn is reduced further to selenide. This oxidated Se state is presumably introduced into selenocysteine, the form at the active site of GSH-Px. Selenide can also be methylated to form dimethylselenide, which is excreted via the lungs, or trimethylselenonium ion, which is excreted by kidneys. Selenomethionine can be incorporated into tissue as such or it can be catabolized to selenide.

Requirements

The minimum Se requirement by ruminant animals is .1 to .3 ppm (NRC, 1980), depending on the status of the animal, the chemical form of the element, and the nature of the rest of the diet, such as vitamin E, sulfur, lipids, proteins, amino acids, copper, arsenic and cadmium. Many researchers indicated that .1 ppm of supplemental dietary Se might be too low in many instances due to a number of factors such as stress, low dietary protein and high dietary sulfur (Essick and Lisk, 1987). As a result of that, the permitted level of Se in all livestock diets was increased to .3 ppm (Fed. Reg, 1987).

Selenium is relatively unstable, so that loses can occur during drying and storing of feedstuffs (McDowell et al., 1983). Also the requirements are greatly dependent on the complex nutritional interrelationships with vitamin E and sulfur containing amino acids. To some extent vitamin E and Se are mutually replaceable (McDowell, 1989).

Tissue Se and GSH-Px concentrations may be used as indicators of Se status (Underwood, 1977). The Se content of hair is a useful indicator of both deficiency and chronic toxicity, and concentration of blood Se is highly responsive to changes in dietary level (Combs et al., 1982; Levander, 1986; Underwood, 1977).

Sources and Supplemental Forms

There is a wide variation in Se concentration in feeds and forages, depending upon the plant species, and particularly on the Se status of the soil where they are grown. All common grasses and legumes vary widely in Se content and may reflect available Se in the soil. In areas where the Se responsive diseases do not occur, concentration of Se in the forage is at least .1 ppm, while in areas with a variable incidence of these diseases the contents are generally below .05 ppm (Underwood, 1977).

The most common form of Se in feeds and forages is protein-bound selenomethionine along with minor amounts of selenocysteine. These forms are well used by ruminants. The naturally occurring Se of plants is apparently much more readily absorbed, and thus more toxic than inorganic forms (NRC, 1989). Topdressed fertilized pastures at a rate of 1 kg Se/ha with Se prills had higher Se concentrations during a six month period than in control pastures. In addition, blood Se and GSH-Px levels of sheep grazing these pastures remained significantly higher over the year as compared to ewes receiving oral Se and grazing unfertilized pastures (Sanson, 1990).

Selenium from natural sources (brewer grains) had greater effect on milk Se concentration than sodium selenite (Conrad and Moxon, 1979). Similarly when Se in wheat was compared with selenite in ewes, Se content of whole blood was higher in sheep fed the high-Se wheat than in those fed the selenite. The greater deposition of Se from organic sources may be due to differences in absorption (Van Ryssen et al., 1989).

Two protein supplements were used to provide supplemental Se to brood cows, soybean meal and linseed meal alone or in combination with sodium selenite. The results indicated that linseed meal + .5 ppm sodium selenite produced the greatest tissue concentrations of Se in cows and calves (Ammerman et al., 1980).

Oral supplementation of Se to pregnant cows increased blood Se of their calves. These calves did not respond to injected Se/vitamin E applied at birth and at 14 days of age, while serum Se concentrations of calves from non supplemented cows increased at 28 and 42 days (Weiss et al., 1984). Sodium selenite was administered orally and subcutaneously to grazing ewes (Langlands et al., 1990), and injected selenite was found to be more effective than oral Se. Elemental Se given alone had no effect on Se status of ewes and their lambs because it was rendered unavailable in the rumen; but Fe:Se pellets were the most reliable form of supplementation in terms of growth rates and blood Se content. The results of two experiments evaluating slow release boluses of Se (3 mg/h/d) for a period of 120 days in suckling beef calves (Phillips et al., 1989), and pregnant beef cows (Campbell et al., 1990) indicated that these boluses were effective in raising blood Se levels as well as in transfer of Se from the dam to the fetus and colostrum as compared to untreated animals.

Vitamin E

Vitamin E is recognized as an essential nutrient for all species of animals, including humans (McDowell, 1989). Compounds of plant origin having vitamin E activity are known chemically as tocopherols and tocotrienols. The side chain of tocotrienols is unsaturated. Four tocopherols and four tocotrienols, α, β, c, and δ, respectively are commonly recognized. Alpha-tocopherol has the highest biological activity.

The dl-α-tocopheryl acetate (also called all-rac-α-tocopheryl acetate) is accepted as the international standard (1 mg = 1 international unit). Synthetic free tocopherol, dl-α-tocopherol, has a potency of 1.1 IU/mg. The naturally occurring d-α-tocopherol (also called RRR-tocopherol) is 1.49 IU/mg, and of its acetate 1.36 IU/mg (McDowell, 1989).

Distribution and Function

Vitamin E occurs in all tissues of the body with the highest concentration in liver (McDowell, 1989). Orally administered α-tocopherol appears rapidly in plasma and tissues. Horwitt (1976) indicates that plasma levels depend upon the interplay of a number of factors, such as the concentration of triglycerides, phospholipids, cholesterol and lipoprotein carriers, rate of removal from the plasma and retention rates in individual tissues. Vitamin E is concentrated in the membrane-containing structures of the cell such as the mitochondria, chromosomes, and plasma membrane (Gallo-Torres, 1980).

Diets adequate in vitamin E are effective in preventing several nutritional diseases including muscular dystrophy, exudative diathesis, encephalomalacia, and liver necrosis (McDowell, 1989). The most widely recognized function of vitamin E, however, is as a natural antioxidant. More recently, the role of vitamin E in the functioning of the immune system in humans and animals has received considerable attention (Bendich, 1988; Reddy et al.,1986; Reddy et al., 1987; Sheffy and Schultz, 1979).

Biological antioxidant

Vitamin E has long been recognized as a natural antioxidant and free radical scavenger (Sheffy and Schultz, 1979). Clinical signs of vitamin E deficiency usually are degenerative in nature and often involve the stability of biological membranes. Vitamin E can function as an intracellular antioxidant to stabilize ingested polyunsaturated fatty acids (PUFA) and the intermediate metabolites resulting from the synthesis and degradation of lipids (Bendich, 1988).

It has been suggested that the biochemical activity of tocopherol is related to its capacity to protect sensitive mitochondrial systems from irreversible inhibition by lipid peroxides. In this fashion α-tocopherol acts as a breaker of free radical chain reactions, and thereby inhibits the destructive peroxidation of PUFA normally associated with membrane lipids (Conn et al., 1987). McDowell (1989) indicates that the consequences of lipid peroxidation involve perturbation of membrane microarchitecture, inhibition of membrane enzyme activity and accumulation of reaction products. The more active the cell, such as in the striate muscle, the greater is the inflow of lipids for energy supply and the greater the risk of tissue damage if vitamin E is limiting. In young animals rapid growth may cause homeostatic mechanisms associated with maintaining the integrity of membrane structures to function at the limit of their capacity (McCay and King, 1980). If the intake of vitamin E in these animals is low, it is possible that tocopherol may not be adequate to provide a sufficient rate of deposition in newly formed membranes to prevent free radical formation when the diets are rich in polyunsaturated fats.

Placental and mammary transfer

Paired maternal-fetal concentrations of α-tocopherol in serum and liver of dairy cattle at slaughter indicated inefficient placental transfer of vitamin E (Van Saun et al., 1989b). Similarly, Stowe el al. (1988) reported no beneficial effect of vitamin E supplementation of dams on serum α-tocopherol of their calves. Therefore, there is minimal protection of the neonate from vitamin E deficiency.

Nutritional muscular dystrophy

As indicated before for Se, NMD may develop intrauterinely or after birth (delayed form). Muth et al. (1961) found that in lambs this disease is also associated with clinical manifestations appearing in areas where soil is deficient in Se. Winter lambs born of ewes which are more or less underfed are the most affected, particularly if the ewe has two or more lambs whose requirements cannot easily be met (Oldfield et al., 1963). Blaxter and Sharman (1953) stated that vitamin E deficiency is accompanied by a Se deficiency which is characterized by white muscle disease (NMD). This disease is manifested in calves which are fed on milk and is associated with rapid growing animals with high nutritional requirements. Clinical signs appear between 15 days and 3 months of age, either in confinement or at the time of pasturing. Clinical signs in confinement appear gradually, while in calves on pasture the syndrome appears when they are released in the spring. They begin by running and jumping, but suddenly one or two may slow down and stand still with a stiff, awkward stance. Then they lie down and are unable to get up. In this case as well as in the lambs, heart and respiratory disorders lead to swift death (King and Maplesdom, 1960).

When both Se and vitamin E are deficient in the diet of animals, particular deficiency syndromes may develop, some of which are responsive to either Se or vitamin E supplementation, or both (Combs and Combs, 1986; McDowell, 1989, Scheffy and Schultz, 1979). Selenium through GSH-Px converts peroxides to water. Combs and Combs (1986) stated that if peroxides are not removed they interact with other cell constituents to form free radicals which proliferate through chain reactions causing structural changes in the cell membranes. Vitamin E a lipophilic molecule is a free radical scavenger. Vitamin E is located in the cell membrane in close proximity to phospholipids and their unsaturated fatty acid moieties, and as a result can terminate chain reactions involving fatty acid peroxil radicals. For some of the vitamin E-Se deficiency conditions, both nutrients can spare each other or can individually prevent appearance of deficiency signs (Combs and Combs, 1986; McDowell, 1989).

Arthur (1988), in an attempt to experimentally develop nutritional myopathy in dairy calves, fed a vitamin E-Se deficient diet to housed calves. He found a large increase in plasma creatine kinase (CK) activity when the vitamin E-

Se deficient calves were turned out to pasture. Plasma CK activity was not increased in calves supplemented with .1 Se/kg as sodium selenite. On the other hand, Maas et al. (1984) reported two cases of nutritional myodegeneration in suckling lambs associated with vitamin E deficiency and normal Se status (blood Se concentration).

Response to diseases

Sheffy and Schultz (1979) indicated that from the cellular perspective the immune system consists of lymphoid components, the T (thymus-dependent components) and the B (bone marrow-dependent) cells, and the macrophage. Another functional class of cells, killer cells, have been defined neither as T nor B cells. These cells require antibodies and are involved in immune phenomenon referred to as antibody dependent cell-mediated cytotoxicity. T lymphocytes represent 60-70% of the lymphoid elements of the blood, while the B lymphocytes represent 10-15% of blood lymphocytes.

Vitamin E is an essential component of cell membranes. If vitamin E is absent from the diet, damage to cell membranes could be predicted including those of lymphocytes (Bendich, 1988). Lymphocytes normally have higher concentrations of free fatty acids than other cells (Reddy et al., 1986).

When laboratory animals were put on vitamin E deficient diets ex vivo T and B lymphocyte responses to mitogenic stimulation were severely depressed, macrophage membrane receptors were altered and interleukin-2 production was lowered. Even in the presence of an antioxidant the vitamin E-deficient cells would not undergo mitogenesis at the level found with lymphocytes from animals fed vitamin E. This indicates that vitamin E must be present during the synthesis of all the cell components so these cells can function optimally (Bendich, 1988).

Larson and Tollesrud (1981) reported that pigs fed a vitamin E and Se deficient diet for 12 weeks had a significantly depressed mitogenic response to phytohematoglutinin (PHA) compared to pigs fed both vitamin E and Se. Addition of Se had some increase in the response, but addition of vitamin E significantly increased these responses. Reddy et al. (1986) reported that lymphocyte stimulation index of dairy calves was higher when they were supplemented with vitamin E than control animals. In a subsequent study calves supplemented with vitamin E exhibited higher lymphocyte blastogenic responses to various T-cell and B-cell mitogens than control calves (Reddy et al., 1987).

Vitamin E and Se have been related to retained placenta, particularly in dairy cows; however, the results of supplementation are controversial. In a two year study Shingoethe et al. (1982) evaluated the response to supplemental Se and vitamin E of dairy cows fed on a Se adequate diet. The results showed that retained placenta was similar for treated and untreated cows. Harrison et al. (1984a) evaluated reproductive performance of dairy cows when supplemental Se and vitamin E were applied 21 days before calving. These results showed 0% incidence of retained placenta in cows supplemented with both Se and vitamin E and 17.5% for cows receiving either Se or vitamin E compared to control cows. They also reported a reduction in the incidence of metritis and cystic ovaries in Se treated cows.

Absorption and Transport

There is only limited information on the mechanisms of absorption, transport and metabolism of vitamin E in ruminants, and especially in calves (NRC, 1989). Gallo-Torres (1980) reported that duodenum is the main site of absorption in ruminants. Intestinal absorption of lipids and fat solubles is dependent on pancreatic function, biliary secretion, micellar formation and penetration across intestinal membranes (Bjorneboe et al., 1990). Gallo-Torres et al. (1971) reported that medium chain triglycerides enhance the absorption process, while long chain PUFA may reduce the absorption of α-tocopherol. Esterified α-tocopherol is completely hydrolyzed and only free tocopherol appears in the chylomicrons in the lymph. Efficiency of absorption of tocopherol is relatively low compared with triglyceride absorption. As the intake increases, the percentage of tocopherol absorbed decreases, suggesting a saturation process. Tissues slowly accumulate tocopherol by transfer from plasma lipoproteins (Bieri, 1990).

Excretion

Gallo-Torres (1980) indicated that feces is the major route of excretion of vitamin E, but it varies widely, ranging from 10 to 75% of the administered dose depending upon the biological product used. Urinary excretion has a minor contribution under normal conditions with approximately 1% of the administered dose appearing in the urine. Similarly, only a small amount of the administered vitamin E appears in the bile.

Requirements

The requirements for young growing beef cattle range from 50 to 60 IU of vitamin E/kg of dry diet (NRC, 1984). Similar figures were given for young growing dairy cattle, and 15 IU/kg of dry diet for lactating dairy cows (NRC, 1989). For sheep of all ages the recommendation is 15-20 IU /kg of dry diet (NRC, 1985). However, the requirements of vitamin E for a given class of animal depend on other factors such as the level of PUFA, Se and sulfur amino acids of the diet. These requirements are often higher when dietary levels of Se and sulfur amino acids are low, as well as when the levels of PUFA, vitamin A, oxidizing agents and other trace minerals are high in the diet. It is important to consider the type of diet or forage being fed. Green fresh forages are good sources of vitamin E, but later in the growing season vitamin E content drops considerably. Also losses of vitamin E in stored forages may be very high, especially ensiled forages such as corn silage (McDowell, 1989; Smith et al., 1988). In addition, high concentrate feeding accelerates preintestinal losses of vitamin E (Alderson et al., 1971).

Assessment of Mineral Status in Ruminants

Several approaches that have been used to establish the deficiency or excess of mineral elements in farm animals including clinical, pathological and biochemical examination of the animals and appropriate tissues and fluids, as well as determination of the amounts and proportions of minerals in the pastures, water or rations (McDowell et al., 1983). The information obtained from any one of the above sources is rarely sufficient to provide conclusive evidence of a specific mineral deficiency or toxicity in animals, so that combinations of them have been used with different degrees of success. Therefore, Underwood (1981) considered that the ultimate criterion of any mineral inadequacy is the improvement in growth, health, fertility or productivity that occurs in response to appropriate changes in intake or utilization of the mineral or minerals in question. McDowell et al. (1986) indicated that most of the mineral imbalances, particularly borderline conditions do not result in pathological observations or clinical signs specific to a single mineral, so in order to determine mineral insufficiencies, chemical analyses and biological assays are required.

Reid and Horvath (1980) indicated that mineral concentration of no single tissue will portray the status of all minerals because the homeostatic control of mineral utilization is exercised in different ways by different elements; consequently, it is important to select organs or fluids for analysis which reflect the nutritional status of the animal. Furthermore, Underwood (1981) indicated that the choice of tissue or fluid for analysis varies with the mineral under investigation. Blood, urine, saliva and hair have obvious advantages because of their accessibility without sacrifice of the animal. Body tissue sampling presents more difficulties, although techniques for liver and bone biopsy are available.

Blood Serum Minerals

Blood and blood components can have great value in diagnosing certain mineral deficiencies or imbalances. Blood has the advantage of ease of collection and relatively easy analysis for most minerals. However, certain factors such as animal stress, exercise, hemolysis, temperature and serum separation time can affect the results of mineral determinations (McDowell et al., 1983). Underwood (1981) indicated that the mineral value in blood plasma or serum which is consistently and greatly above or below the so called normal concentration provides suggestive, but not conclusive evidence of a dietary excess or deficiency of a particular mineral.

Calcium and phosphorus

Underwood (1981) indicated that phosphorus (P) deficiency is predominantly a condition of grazing ruminants, especially cattle, whereas calcium (Ca) deficiency is more a problem of hand-fed animals, especially pigs and poultry. The extensive areas of P deficiency in grazing livestock that occurs throughout the world arise mostly from a combination of soil and climatic effects on herbage P concentration. Calcium level in blood plasma has been used as an indicator of the Ca status of grazing ruminants (Underwood, 1981). He suggested 9-11 mg Ca/100 ml blood plasma as the normal level. According to Cunha et al. (1964) values of 10-12 mg in blood serum are normal for healthy cattle, with deficiency occurring when the values fall below 8 mg/100 ml. Serum Ca levels are usually maintained at approximately 10 mg/100 ml through regulatory mechanisms of the body with the combined action of three hormones parathyroid, calcitonin and vitamin D_3 (Underwood, 1981).

Despite some limitations serum or plasma inorganic P concentration has been used extensively and, because of practical consideration, probably would be the most useful diagnostic procedure in assessing P status in cattle (Teleni et al., 1976). Underwood (1981) also suggested that P status of grazing animals is determined best by serum or plasma inorganic P levels.

Underwood (1981) described some of the changes in blood as a result of dietary P deficiency. The first response is a fall in the inorganic phosphate fraction of the blood plasma and a withdrawal of Ca and P from bone reserves. In addition to this decline plasma phosphatase increases and plasma concentration increases from the normal 9-10 to 14 mg/100 ml. He also suggested that the normal values for plasma inorganic P are 4-6 mg/100 ml for adults and 6-8 mg/100 ml for very young animals. Kiatoko et al. (1982) reported plasma P values ranging from 5 to 6 mg/100 ml for cattle in Florida. Salih et al. (1987) reported P concentrations in cows higher at parturition than at three months post-partum in North Florida.

Magnesium

Magnesium (Mg) concentration in plasma does not fall until conditions of a severe deficiency are reached (McDowell et al., 1983). The NCMN (1973) indicated that Mg status of ruminants is assessed best from Mg concentration in blood and urine. They suggested that normal serum Mg concentrations range from 2.0 to 3.5 mg/100 ml. Values below 2.0 mg/100 ml are considered deficient and below 1.0 mg/100 ml extremely deficient. Furthermore, Underwood (1981) reported that serum Mg concentrations below 1.7 mg/100 ml were found in cattle suffering from hypomagnesemic tetany. Cunha et al. (1964) reported values of 2.5 mg/100 ml in normal cattle in Florida. From Florida, Salih et al. (1987) reported higher levels of plasma Mg at parturition than three months later.

Copper

Copper (Cu) plays an important role in hemoglobin synthesis as well as in red blood cell maturation (Maynard et al., 1979). A number of metalloenzymes containing Cu were identified in cells and tissues, including ascorbic oxidase, lysil oxidase, cytochrome oxidase, ceruloplasmin and superoxide dismutase (Underwood, 1981). McDowell et al. (1984) states that with the exception of P, Cu deficiency is the most severe limitation to grazing livestock throughout tropical regions. The most widely used criteria for assessing Cu deficiency is Cu concentration in liver and blood. Whole blood or plasma Cu concentrations reflect dietary status (Underwood, 1981). He suggested that the normal range of whole blood or plasma Cu in cattle, sheep, and goats is .6 to 1.5 ppm, with most values between .8 to 1.2 ppm.

According to the NCMN (1973) plasma Cu concentrations of .6 to .75 ppm may be considered slightly deficient, while values below .4 ppm suggest Cu deficiency. McDowell et al. (1984) suggested a critical level for serum Cu in cattle of .65 ppm. Blood Cu concentration can be affected by many factors including age, pregnancy, disease, as well as dietary Cu, molybdenum and sulfur (Kincaid et al., 1986; McDowell et al., 1983).

In Florida studies, Cunha et al. (1964) suggested that normal blood Cu concentration in the healthy mature bovine is .75 ppm. Salih et al.(1986) reported serum Cu values ranging from .60 to .65 ppm in Brahman cattle. Merkel et al. (1990) reported serum values of .45 to .72 ppm for serum Cu in Charolais cattle. McDowell et al.(1982) reported plasma Cu values of 1.0 and .8 ppm for cattle during the wet and dry seasons, respectively.

Zinc

Zinc (Zn) functions as an activator and constituent of more than 30 enzymes that are involved in nucleic acid metabolism, protein synthesis and carbohydrate metabolism (Underwood, 1977). The utilization of amino acids in the synthesis of protein is impaired in Zn deficiency. The highest concentrations of Zn in the body are found in epidermal tissue such as the skin, hair and wool; traces also occur in bones, muscle, blood and various organs (Maynard et al. (1979). According to NCMN (1973) Zn status of animals could be assessed in blood plasma, with Zn values ranging from .6 to 1.4 ppm indicating normal Zn status. McDowell et al. (1984) presented a range of .6 to .8 ppm as the critical level.

Plasma Zn levels respond to dietary changes. Mills et al. (1967) reported a sharp decline in serum Zn from normal values of .8 to 1.2 ppm to below .4 ppm in lambs and calves after one week of being fed a Zn deficient diet. Prabowo et al. (1991) reported serum Zn values ranging from .67 to 1.15 ppm in Bali cattle.

Iron

Iron (Fe) is a constituent of hemoglobin, myoglobin, cytochromes and many other enzymes (Maynard et al., 1979). Iron deficiency is of limited practical significance, with the exception of suckling piglets (Underwood, 1981). There are few reports of Fe deficiency in grazing animals. However, conditions involving severe blood loss such as parasite infestation which may cause severe anemia may cause Fe deficiency (Underwood, 1981). McDowell et al. (1984) suggested Fe supplementation under conditions where Fe content of forages is lower than 100 ppm and/or when insects or parasites are causing substantial blood loss. McDowell et al. (1985d) suggested 1 ppm as the critical level for serum Fe in cattle.

Selenium

Selenium occurs in all cells and tissues of the body in concentrations that vary with the tissue, the amount, and chemical form of Se in the diet. Blood Se content is very responsive to dietary Se intake and as a result Se toxicities and deficiencies have been detected in humans and animals (Levander, 1986). In animal tissues Se is incorporated into protein as Se analogues of the sulfur containing amino acids and as the main functioning form of Se GSH-Px.

Selenium is readily transported through the placenta to the fetus, even in the presence of low maternal Se concentrations (Koller et al. 1984). The minimum Se level suggested for ruminant animals is .1 to .3 ppm (NRC, 1980). The level of .3 ppm is the highest level permitted for all livestock diets (Fed. Reg., 1987). Tissue Se and GSH-Px concentrations may be used as indicators of Se status (Underwood, 1977). McDowell and Conrad (1977) suggested .03 ppm as the critical serum level for cattle. Prabowo et al. (1991) reported serum Se contents ranging from .05 and .14 ppm in Bali cattle.

Hair Selenium

Mineral content of hair is affected by season, breed, hair color within and between breeds, sire, and age (Combs et al., 1982). Selenium concentration in hair reflects dietary intake (Underwood, 1977; Combs et al., 1982). Hair from normal cows contains 1 ppm compared with 30 ppm for cattle in seleniferous areas (Underwood, 1981). Hidiroglou et al. (1968) reported that cows with hair Se concentrations between .06 and .23 ppm produced calves with WMD, while no WMD was observed in calves from cows with hair Se concentrations greater than .25 ppm. Olson (1969) indicated that continuous Se intake of 5 ppm by cattle may result in selenosis and that concentrations of 5 to 10 ppm Se in hair of cattle may indicate Se toxicity. Injected and oral Se supplementation during the dry period increased hair Se concentration of the dams and their calves (de Toledo and Perry, 1985).

Liver Minerals

Underwood (1981) indicated that liver is a very useful tissue to determine animal status due to its storage capacity for certain minerals and because simple biopsy techniques enable representative tissues samples for analysis without sacrifice of the animal. Subnormal concentrations of Fe, Cu and cobalt (Co) in the liver are indicative of dietary deficiencies of these elements. McDowell et al. (1986) indicated that liver taken either from biopsy or from sacrificed animals is an excellent indicator of the status of Co, Cu, Fe, or Se.

Copper

Liver is the storage organ for body Cu with concentrations varying with the species and age of the animal, certain disease states and nature of the diet (McDowell et al., 1983). Liver Cu concentrations reflect dietary status (Mills et al., 1976). Copper concentrations are influenced by the dietary proportions of molybdenum (Mo) and S, by high intakes of Zn and Ca, so caution must be taken when using them as diagnostic aids (McDowell et al., 1983). McDowell (1987) suggested 25 ppm as the critical level of liver Cu for cattle. According to NCMN (1973) liver Cu concentrations of 200 and 150 ppm on dry matter basis (DMB) are considered normal for yearling and adult females, respectively. They also reported liver Cu values of 25 ppm as marginal, while levels below 10 ppm usually followed clinical signs of Cu deficiency. Underwood (1981) indicated that normal liver Cu values range from 100 to 400 ppm (DMB). Cunha et al. (1964) considered levels of liver Cu between 100 and 300 ppm normal, 75 ppm marginal and below 25 ppm Cu (DMB) often were accompanied by severe clinical Cu deficiencies. Espinoza et al. (1991a) reported values of 190 to 313 ppm liver Cu in Central Florida.

Zinc

Zinc deficiency is probably more common in grazing ruminants than normally expected. Liver is the major organ of Zn metabolism in the body (McDowell et al., 1983). Miller and Miller (1962) considered values from 84 to 132 ppm as the normal Zn levels in liver for cattle, whereas Underwood (1977) suggested that liver Zn values above 125 ppm should be considered as the normal value for cattle.

Factors that reduce Zn absorption in the gastrointestinal tract such as phytic acid, Ca, Mg, P, Cu and chelating agents such as EDTA have also been found to reduce Zn concentration in liver (Miller , 1975). McDowell (1985d) suggested a critical level for liver Zn of 84 ppm.

Iron

Determination of Fe deficiency is assisted by hemoglobin and percent saturation of transferrin (McDowell et al., (1983). According to Underwood (1981), ferritin is the main Fe storage compound and its concentration along, with hemosiderin in tissues reflects the Fe status of the animal. Ammerman (1970) reported levels of 100 to 300 ppm Fe (DMB) in Florida cattle with adequate Cu nutrition. McDowell 1985d) suggested 180 ppm as the critical level for liver Fe.

Manganese

The NCMN (1973) considers liver tissue the most promising criteria for assessing Mn status of animals. The ARC (1980) indicated that the highest concentrations of Mn are found in the liver, hair and skeleton. The normal level of Mn in cattle is 8 to 10 ppm, according to Underwood (1977), and levels below 8 ppm indicate deficiency. Egan

(1975) suggested that liver Mn levels below 6 ppm may indicate deficiency. Later, McDowell (1985c) suggested 6 ppm as the critical level.

Cobalt

The concentration of Co in the liver of cattle and sheep is responsive to changes in Co intake. Livers of normal healthy sheep and cattle irrespective of their age usually contain .2 to .3 ppm Co (DMB), while those of deficient animals rarely contain more than .04 to .08 ppm (Underwood, 1981). McDowell (1985b) suggested that Co levels between .05 to .07 indicate deficiency and those above .07 ppm can be considered normal.

Molybdenum

Molybdenum (Mo) is an essential constituent of xanthine oxidase, aldehyde oxidase and sulfide oxidase; the activity of these enzymes declines in experimental deficiency (Nielsen and Mertz, 1984). Toxicosis is the main concern with Mo in ruminant nutrition. Clinical signs of Mo toxicosis in cattle include diarrhea, anorexia, achromotrichia and posterior weakness (NRC, 1980). Underwood (1977) suggested 2 to 4 ppm as the normal values for liver Mo. Furthermore, McDowell (1985d) suggested that liver values above 4 ppm may indicate Mo excess.

Selenium

Langlands (1987) suggested that fluids and liver reflected Se status in animals. Underwood (1977) reported that liver and kidney contain high concentrations of Se and are very sensitive to dietary Se. Liver Se levels below .25 ppm (DMB) were considered deficient (Andrews et al., 1968). McDowell et al. (1985) suggested .25 ppm as the critical level for liver Se. Van Saun et al. (1989a) reported efficient placental transfer in Se supplemented dry cows as indicated by higher fetal liver Se concentrations than the corresponding maternal liver Se.

Milk Minerals

Mineral composition of milk varies with the animal species, the stage of lactation and the incidence of various diseases. In general milk is a rich source of Ca, P, K, Cl and Zn, but not a satisfactory source for elements such as Mg, Cu, Fe and Mn (Underwood, 1981). He also indicated that milk yield is affected by low dietary levels of Ca, P, Na and Fe, but the concentration of these minerals in secreted milk is not affected. By contrast, dietary deficiencies of Cu and iodine result in a marked decline in the concentration of these elements in milk produced.

Andrews (1990) indicated that colostrum is not a single entity since the composition changes rapidly and becomes closer to that of normal milk with each milking or suckling of the newborn. Colostrum is rich in many vitamins and minerals which tend to be low in milk. Heifers colostrum also tends to be less concentrated than in cows.

Calcium, phosphorus, magnesium

Compared to normal milk, colostrum has high concentrations of Ca, P and Mg, but the levels of these minerals drop to normal levels after colostrum has ended (Corbin and Whittier, 1974; Andrews, 1990). Levels of these three minerals in milk of crossbred Indian cattle increased throughout the lactation period (Mathapati and Bhat, 1988). In Brahman cattle in Florida, Salih et al. (1987) reported higher levels of P and Mg three months post-partum than at parturition. Underwood (1981) listed representative values for milk minerals of farm animals. The reported values for cow's milk were .12, .10, and .01 grams of Ca, P and Mg/100 grams of milk, respectively; while for ewes the values were .19 and .15 for Ca and P, which indicates greater concentrations in ewes milk for these minerals than cows milk.

Sodium chlorine and potassium

Some of the signs of Na (salt) deficiency after a long depletion period in cattle include loss of appetite, unthrifty appearance, rough hair coat, lower growth rates and decreased milk production (Miller, 1979). It was also indicated that Na and chloride content of milk are not affected by the amount of feed and reported Na values for dairy cattle ranging from .042 to .105%, and an average of .115% for milk chloride content. Furthermore, McDowell et al. (1983) indicated that Na deficiency could occur during lactation due to Na secretion in milk, and even after prolonged severe deficiency NaCl secreted in milk remained high.

According to Corbin and Whittier (1974) Na and K act inversely with regard to their changes in concentration between colostrum and normal milk. Sodium is higher in colostrum, then quickly falls to normal levels and increases throughout lactation. Conversely, K levels are low in colostrum increasing to normal at 2 months and then decline throughout lactation in dairy cattle. Miller (1979) indicated that in a severe K deficiency milk production decreases with a slight decrease in milk K concentration. Storry et al. (1983) listed concentrations of minerals in milk from sheep and cows. Potassium concentration ranged from .10 to .14% for both species; whereas Underwood (1981) listed values of .15 and .19% for cows and ewes respectively. Milk Na values for cows ranged between .04 to .11 and for ewes .04 to .05 (Storry et al., 1983).

Trace elements

Considerable attention has been focused on the Cu content of milk due to its catalytic effect on the development of oxidized flavor of milk and milk products (Corbin and Whittier, 1974). Furthermore, inadequate Cu intake reduces milk Cu concentration (Underwood, 1977). Cows milk is quite low in Cu but if the dam's intake of Cu is adequate, the newborn will have a substantial store of Cu in the liver (Miller, 1979). Milk Cu content of dairy cows generally varies below .1 ppm with many between .04 and .07 ppm, but amounts as high as .2 ppm are not unusual after calving. Archibald (1958a) gave a range of .10 to .16 ppm for milk Cu and indicated that Cu concentration is highest early in lactation but decreases with lactation. Underwood (1981) listed values of .2 ppm for both ewes and cows milk. De Maria (1978) reported Cu concentrations of colostrum and milk (3 days post-partum) from several species; the values for ewes were 1.2 and .5 ppm and for cows .30 and .19 ppm for colostrum and milk, respectively.

Zinc is present in higher concentrations in milk than any other trace element. Underwood (1981) listed a representative value of 4 ppm. Archibald (1958b) reported 3.7 ppm for cows milk.

Most of the Zn in milk is associated with protein, especially casein (Miller, 1979). Milk Zn responds to concentrations of dietary Zn. Miller et al. (1965) fed dairy cows up to 2000 ppm supplemental Zn and raised milk Zn levels to 8.4 ppm. The authors concluded that milk Zn levels did not progressively increase as much as dietary Zn levels. De Maria (1978) reported Zn concentrations of 14.7 and 5.4 ppm in colostrum and milk of ewes, and 7 and 4.2 ppm for colostrum and for cows milk three days after parturition, respectively.

Underwood (1971) indicated that the level of Mn in milk can be increased 2 to 4-fold by feeding large amounts of Mn. Lönnerdal et al. (1981) reported values of Mn in colostrum ranging from .10 to .16 ppm and in milk ranging from .02 to .05 ppm for both cows and ewes. De Maria (1978) reported Mn concentrations of colostrum of .24 ppm in ewes and .12 ppm in cows.

Underwood (1977) indicated that Fe in milk is very low and does not change materially with increased dietary Fe. Lönnerdal et al. (1981) reported values in colostrum of .5 to .7 ppm for cows and .4 to 1.0 ppm for ewes, and in milk .2 to .3 ppm for cows and .4 to .6 ppm for ewes. De Maria (1978) concluded that in ewes the concentration of Cu, Zn, Mn and Fe fall by more than 50 % during the first three days of lactation.

Natural colostrum has greater concentrations of Se than regular milk. In addition, prepartum supplementation of the dam can increase colostrum Se concentrations (Campbell et al., 1990; Salih et al., 1987; Stowe et al., 1988). Other researchers have found no effect of supplemental Se on colostrum Se (de Toledo and Perry, 1985) or low response to supplementation in milk Se concentrations (Conrad and Moxon, 1979). The response to supplemental Se was obtained only when dietary Se was deficient (Maus et al., 1980).

Mineral Status of Soils and Plants

Most mineral deficiencies in grazing animals occur on infertile soils under extensive systems of grazing management and are often accompanied by deficiencies of energy and protein (McDowell et al. 1984). Other deficiencies, however, are related to intensive systems of production, for example Mg where the nutrient supply from herbage fails to meet the high animal requirements. For most mineral elements herbage mineral content is determined by the availability of soil minerals, which is influenced by factors such as soil pH and water content. In fertilized pastures the content of Ca, P and K is mainly influenced by fertilizer applications (Jones and Wilson, 1987).

Forages often are the sole component of a grazing animal's diet; consequently, those animals must depend almost exclusively on those forages to supply their total mineral requirements. McDowell et al. (1984) states that only rarely can tropical forages completely satisfy all mineral requirements.

Mineral composition of forage plants is affected by soil-plant factors including soil pH, fertilization, drainage, maturity and plant species, as well as interaction among minerals (Gomide, 1978; Reid and Horvath, 1980). Plants take up minerals rapidly during early growth but, as growth accelerates dry matter accumulates more rapidly than minerals are taken up, with the result that the content of most minerals decrease with advancing maturity. Leaf is almost invariably higher in minerals than the stem, and this also contributes to the decline with age as proportion of leaf in the forage decreases (Jones and Wilson, 1987). However, Montalvo et al. (1989) reported higher concentrations of K, Mg, P and Zn in stems of dwarf elephant grass than in leaves under grazing conditions in Florida.

Macrominerals

Liming greatly increases uptake of some trace minerals due to its effect on soil pH. McDowell et al. (1984) summarized some of these effects indicating that availability and uptake of Fe, Mn, Zn, Co and Cu decrease with liming, whereas Mo and Se increase. Some acidity problems are associated with pH levels lower than 5.5 concomitant with the presence of exchangeable Al in the soil (Sanchez, 1981). Above pH 5.5 soil Ca is generally adequate for pasture growth of most species. Below 5.5 many plants exhibit poor growth and herbage production caused by excess soluble Mn, Fe and/or Al, rather than by Ca content (Warncke and Robertson, 1976). Breland (1976) using the double acid extraction method of analysis for Florida soils ranked Ca in the soil solution as follows 0 to 71 ppm, low; 72 to 140 ppm, medium and greater than 140 ppm high.

Phosphorus deficiencies in soils and pastures are very common in tropical acid soils, and after nitrogen (N) no other element has been as critical to the growth of plants (Brady, 1984). Low availability of soil P may be due more to soil acidity or alkalinity resulting in the formation of Fe or Al complexes with phosphate (Beeson and Matrone, 1976). In most livestock grazing areas of tropical countries soils and plants are low in P for the greater part of the year, and mature forages contain less than .15% P (McDowell et al., 1984). Analysis of soils using the double acid extraction method, indicated that a P content in the soil solution of 0 to 5 ppm is very low; 6 to 13 is low; 14 to 25 ppm medium and 26 to 50 ppm is considered very high in P (Breland, 1976; Bahia, 1978). The extractant used was later referred to as the Mehlich I extractant by the Soil Science Society of America (Rhue and Kidder, 1983).

Most soils are relatively high in K, except sandy soils. This element is mostly fixed in the primary mineral or is found in forms that are only moderately available to plants (Rhue and Street, 1980). Approximately 90 to 98% K in a mineral soil is unavailable (Blue, 1974; Tisdale and Nelson, 1975). Most K losses from the soil occur through crop removal, and leaching, which is usually high in sandy and low exchange capacity soils (Rhue and Street, 1980). Forage K concentration changes during growth for physiological reasons independent of the soil K level (Grimme, 1976). Normal K content in young forages ranges from 1.0 to 2.5 of the DM. Bahia (1978) using the double acid extraction method of soil analysis presented the criteria for available K in soils as follows: 0 to 60 ppm, low; 61 to 120 ppm, average; and greater than 120 ppm, high.

Metson (1974) reviewed the factors affecting the availability of soil Mg and stated that the amount of Mg in the soil is strongly influenced by the process of weathering. Thus only a small proportion of the total Mg present in the soil is available to the plant. Christenson and Doll (1978) indicated that the total Mg uptake by plants was not related to the total Mg levels in the soil. Sanchez (1981) indicated that many acid soils in the tropics are deficient in Mg without having Al toxicity problems, therefore, these soils respond directly to fertilization. Using the double acid extractant method of analysis for Florida soils Breland (1976) reported values of Mg from 0 to 9.1 ppm as low, 9.2 to 21.1 ppm as medium and more than 21.1 ppm as high. In a later report Rhue and Kidder (1983) indicated that for agronomic and vegetable crops grown in acid soils in Florida, the amount of Mehlich I extractable Mg is interpreted as follows: less than 30 ppm, low; 31 to 60 ppm, medium and more than 60 ppm high.

A forage Mg concentration of .2% is considered the critical level associated with grass tetany in cattle (Underwood, 1966; Karlen et al., 1980).

Sodium is one of the most loosely held of the metallic ions and is readily lost through leaching. Its presence in soils in high quantities is restricted to arid and semiarid regions (Tisdale and Nelson, 1975). Sodium deficiency is relatively common, since forages are generally low in Na.

Trace Minerals

Available Cu in the soil is present as cupric ion (Cu^{+2}) and in this form it is usually absorbed by plants (Tisdale and Nelson, 1975). Among the factors affecting soil Cu levels are parent material, organic matter, clay concentration and soil pH (McLaren et al., 1983). Copper content of soil ranges from 2 to 50 ppm with the greatest concentration in the surface horizon bound to organic matter and clay minerals (Reid and Horvath, 1980). Rhue and Kidder (1983) suggested .3 ppm soil Cu as the critical value for plants. The normal content of Cu in plants ranges from 8 to 20 ppm, and deficiencies may occur at 6 ppm (Jones, 1972). Underwood (1981) indicated that Cu deficiency in ewes can be found with high intakes of Mo and sulfur and normal Cu intake.

It has been reported that few if any soils are deficient in total Fe (McDowell et al., 1984). However, the solubility may be the problem in the iron forms of hydroxide and oxide (Linsay, 1972). Iron content in forages varies widely and can be greatly affected by soil contaminants (Jones, 1972). Viets and Lindsay (1973) suggested 2.5 ppm in the soil as a critical value.

The Zn content of Florida soils ranges from 10 to 30 ppm (Street and Rhue, 1980b). In general the extractable levels of Zn increase with organic matter content. Liming reduces the availability of Zn to plants. Also, high frequency of Zn deficiency is observed on high phosphate soils (Olsen, 1972).

Manganese occurs in soils in many different chemical forms, most of which are not readily available to growing plants (Street and Rhue, 1980a). The most important factors controlling solubility and availability of Mn are the oxidation and reduction states, and soil pH. In wet soils (reduced conditions), Mn is solubilized, while in dry soils (oxidizing condition) Mn is precipitated or immobilized. The soil pH at which Mn is most available is between 5.0 to 6.5; soil Mn varies from 20 to 6000 ppm (Street and Rhue, 1980a). Mooso (1987) reported soil Mn values in Florida from .9 to 2.2 ppm. Manganese content in forages is extremely variable, mainly due to species differences as well as soil and fertilizer effects (Underwood, 1977). Most forages contain 30 ppm Mn and as a result can meet the requirements of 10 to 20 ppm Mn for heifers and cows (NRC, 1976).

Cobalt plays an important role in N fixation by bacteria (Brady, 1984). Forage concentration of less than .07 ppm Co/kg DM are inadequate for sheep and somewhat lower concentration of Co are inadequate for cattle (Langlands, 1987). Furthermore, Houser et al. (1978) suggested that forage Co concentrations less than .10 ppm should be considered deficient for cattle. Becker et al. (1965) reported values of .000 to .035 ppm forage Co in pastures with salt sick in Florida. Espinoza et al. (1991c) reported Co values ranging from .03 to .07 ppm in Central Florida cattle.

In general Mo availability is high in soils rich in organic matter, alkaline and soils derived from volcanic materials; whereas, Mo deficiencies are associated with soils below pH 5.5 (Mortvedt et al., 1972; Davis, 1974). Large (1971) reported that Mo levels of .4 ppm are adequate for most crops. Underwood (1977) indicated that Mo toxicity generally occurs in cattle grazing pastures with 20 to 100 ppm but not in cattle grazing normal pastures with 3 to 5 ppm Mo or less. Furthermore, he indicated that below .2 ppm of Mo, Cu toxicity may develop. Becker et al. (1965) reported forage Mo levels ranging from 1 to 160 ppm. Espinoza et al. (1991c) reported values from 23 to 76 ppm.

Selenium content of the soil has shown little relation with Se content of the forage. One possible reason seems to be due to the differences in chemical form of soil Se which are closely related to the oxidation-reduction potential and pH of soils, since these forms vary widely in their solubility (Lakin, 1972). Ammerman et al.(1978) suggested that Se content in plants depends not only on soil factors, but also on plant species, maturity, yield and climate. The

Se content of soil is determined by the Se content of the host rock, pH and drainage (Cooper et al., 1974). Cary et al. (1967) indicated that soil Se below .5 ppm is prevalent in areas where Se deficient animals have been reported. McDowell et al. (1982) suggested .2 ppm as the critical level for soil Se. Espinoza et al. (1991c) reported values in Florida forages ranging from .04 to .11 ppm.

CHAPTER III
MATERIALS AND METHODS

Description of Research

Four experiments were conducted in north Florida to evaluate the effect of supplemental Se and vitamin E to beef cattle and sheep on tissue and fluid concentrations. Experiments 1 and 2 were carried out with beef cattle on two farms located 21 and 20 miles south of Gainesville, near Bronson and Williston, respectively. Experiment 3 was conducted at the Pine Acres Research Unit of the University of Florida using 63 pregnant beef heifers and experiment 4 was conducted with 21 pregnant ewes on the Sheep Research Unit of the University of Florida.

Experiments 1 and 2

Several disease problems were reported in beef cattle grazing native pastures on sandy soils near Bronson; however, on soils with a more clayey type of texture (Archer and Williston) these problems were not recorded at that time. The disease problems included severe scours and pneumonia, as well as a disease condition resembling shipping fever in calves, and Heinz body anemia in cows.

Several attempts to solve those problems were unsuccessful or uneconomical and as a result, a nutritional study using supplemental Se and vitamin E was carried out on two farms, one located in the problem area near Bronson and the other one at Williston where cattle never exhibited those disease conditions.

These experiments were conducted with beef cows and their calves. Cows were ¼ to ½ Angus, crossbred with Hereford, Charolais and Brahman, over three years of age. Animals grazed on bahia grass (*Paspalum notatum*) pastures through the experimental period, and each group was fed a mineral supplement which contained monensin. Analysis of the free-choice mineral supplement provided to all the animals was: Ca, 15.7%; P, 6.3%; Mg, 2.0%; K, 0.3%; Na, 11.0%; Mn, 2400 ppm; Fe, 7300 ppm; Zn, 2640 ppm; Cu, 448 ppm; Co, 16.4 ppm; Mo, 10.8 ppm; and Se, 0.8 ppm.

Experiment 1. In June 1988 a group of 48 pregnant cows was randomly assigned to two treatments at each farm as follows: 1) Control (no supplemental Se) and 2) supplemental Se. Selenium as sodium selenite was administered as part of the free-choice mineral supplement to provide 23 ppm Se. The average consumption of the mineral supplement was 65 g/h/d and the Se consumption was 1.5 and .052 mg/h/d for the Se treated and control animals, respectively.

Experiment 2. In March 1989 additional treatments with and without vitamin E were included in combination with each level of Se. A group of 80 pregnant cows was randomly assigned to the four treatments at each farm as follows: 1) Control (without supplemental Se or vitamin E); 2) vitamin E; 3) Se; 4) Se + vitamin E.

Vitamin E was administered in boluses of 20 g/cow, in both June and March 1989. This commercial product provided 10,000 IU of α-tocopherol per animal at each time. The Se treated animals at Bronson also received Se as sodium selenate in the drinking water from March to July 10, 1989. The average consumption of the mineral supplement was 65 g/h/d. Combining Se from both the mineral supplement and water, the average Se consumption, other than pasture would be 2.1 and 1.5 mg/h/d for the Se treated groups at Bronson and Williston, respectively. The level of supplemental Se administered in both experiments was chosen to provide the requirement (.2 ppm) for beef cattle NRC (1980).

Sample Collection

For experiment 1, soil, forage, milk, liver and hair samples were collected in June and October 1988. For experiment 2, forage and soil samples were collected during the grazing season, in March, May, June, August and October 1989. Blood and hair from cows were collected in March, June and October. Liver and milk samples from cows and blood samples from calves were collected in June and October 1989.

Soil Samples

Three to five composite soil samples from each of the two pastures in each of the two locations were collected in each sampling date using a stainless steel sampling auger at a depth of 15-20 cm. Samples were collected in plastic bags, dried at 60°C for 48 hr, passed through a 2 mm sieve and stored at room temperature until chemical analysis.

Forage Samples

Forage samples were collected randomly in every pasture, at the same time and place as the soil samples. Forage samples were packed into paper bags and dried at 60°C for 48 hr at the Animal Nutrition Laboratory of the University of Florida. Then forage samples were ground using a Wiley mill with a 1 mm stainless steel sieve. Ground forage samples were stored in plastic bags for the corresponding chemical analysis.

Animal Tissue Samples

Blood samples for chemical analysis were taken by jugular puncture in two 15 ml vacutainers and were centrifuged at 700 g for 20 min. Serum samples were processed and analyzed by the procedures described by Fick et al. (1979). Serum samples for lymphocyte blastogenic response were collected by jugular puncture into 60 ml blood collection tubes using acid citrate as an anticoagulant.

After collection these samples were placed in a cooler with ice and transported to the immunology laboratory where they were processed the following day.

Hair samples

Hair samples from cows were collected simultaneously with blood samples. Hair was clipped from the flank and rib of the animal using electric clippers, stored in plastic bags in the laboratory, washed with a Se-free commercial shampoo, rinsed twice with acationic detergent and dried for chemical analysis.

Milk samples

Milk samples were collected in 125 nalgene bottles using the first drawn milk. All animals were sampled shortly after administration of one ml oxytocin injection to stimulate milk let down. Milk samples were stored frozen in the laboratory until chemical analysis.

Liver biopsies

Liver biopsies were collected using the technique described by Fick et al. (1979). Liver samples were kept in plastic bags and stored frozen for subsequent analysis.

Sample Preparation and Chemical Analysis

Forage samples and animal tissues collected were brought to the Animal Nutrition Laboratory at the University of Florida for chemical analysis. Soil samples were dried, prepared and brought to the IFAS Extension Soil Testing Lab for chemical analysis. A summary of all analyses performed on samples collected in these two experiments is shown in Table 1.

Soil Samples

Soil samples were analyzed for pH, OM, Ca, P, K, Mg, Na, Cu, Zn, Fe, Mn and Al by the procedures used by the IFAS Extension Soil Testing Lab at the University of Florida (Rhue and Kidder, 1983). Soil minerals were extracted using the Mechlich I extracting solution method (Rhue and Kidder, 1983). Mineral concentrations were determined by the Inductive Argon Plasma (ICAP) Thermo Jarrel Ash, Model 9000, Franklin (Jarrel-Ash division,1982).

Forage Samples

Forage samples were prepared and analyzed for mineral concentrations following the methods described by Fick et al. (1979). Ca, K, Mg, Na, Cu, Zn, Fe, and Mn concentrations were analyzed by atomic absorption spectrophotometry (Perkin-Elmer, 1980). Cobalt and Mo were analyzed by flameless atomic absorption spectrophotometry on a Perkin-Elmer 3030 graphite furnace with Zeeman background correction (Perkin-Elmer, 1984). Nitrogen and P concentrations in forage were determined on a Technicon Auto Analyzer II, following the method described by Gallaher et

TABLE 1. ANALYSIS PERFORMED ON COLLECTED SAMPLES (EXPERIMENTS 1 AND 2)

Sample	Element(s) Analyzed
Serum	Ca, P, Mg, Cu, Zn, Fe, Se, Vitamin E, PHA, Con A, IL-2.
Liver	Cu, Zn, Fe, Mn, Co, Mo, Se.
Milk	Ca, P, K, Mg, Na, Cu, Zn, Se.
Hair	Se.
Forage	Ca, P, K, Mg, Na, Cu, Zn, Fe, Mn, Co, Mo, Se, crude protein.
Soil	pH, OM, Ca, P, K, Mg, Na, Cu, Zn, Fe, Mn, Al, Se.

PHA = phytohematogglutinin, Con A = concanavalin A, IL-2 = human recombinant interleukin-2.

al. (1975) and Technicon Industrial systems (1978). Selenium concentrations in forage and soil samples were determined following a modification of the fluorometric procedure described by Whetter and Ullrey (1978).

Animal Tissue Samples

Blood serum samples were deproteinated with 10% trichloroacetic acid (TCA) and 1% lanthanum chloride ($LaCL_3$) and analyzed for mineral content according to procedures described by Fick et al. (1979). Calcium, Mg, Cu, Zn and Fe were analyzed by atomic absorption spectrophotometry with a Perkin-Elmer 5000 (Perkin-Elmer, 1980). Phosphorus concentration was determined using a colorimetric procedure described by Harris and Popat (1954). Selenium concentration in blood serum was determined using the modified fluorometric procedure of Whetter and Ullrey (1978).

Vitamin E in serum of cows and calves was analyzed as α-tocopherol by high pressure liquid chromatography (HPLC). A 500 μL serum sample was used for the analysis. Ethanol was added to precipitate the serum proteins and double extraction with isooctane. Analysis of α-tocopherol followed the method of Cort et al. (1983) and was amended as follows: The HPLC used consisted of a Perkin-Elmer Series 4 Liquid Chromatograph, a Perkin-Elmer LS-4 Fluorescent Spectrophotometer with excitation at 290 nm and a slit setting of 10, a Perkin-Elmer ISS-100 Autosampler equipped with a 50 µL loop and a normal phase Lichrosorb SI60 (5 µm) column 25 cm X 4.0 mm i.d. (E Merk Hi Bar). Chromatographs are recorded and peak areas are determined by using a Perking-Elmer LCI-100 integrator. The mobile phase is 5% (v/v) tetrahydrofuran (HPLC) in 95% isooctane (HPLC) with a flow rate of 1.0 ml/min. The injection volume is 50 µL. Quantifying α-tocopherol was by comparison of retention time and peak areas with D-α-tocopherol standard.

Blood samples for lymphocyte blastogenic response were centrifuged at 700 g for 20 min. and white blood cells (WBC) were then harvested with a Pasteur pipette and mixed with phosphate-buffered saline (PBS) for a total volume of 10 ml. The WBC and the medium were then layered on 5 ml Ficoll/Hypaque and centrifuged at 700 g for 40 min. Lymphocytes sedimented at the interface between ficoll and medium were collected with a Pasteur pipette, washed twice with RPMI-1640 medium and then resuspended in RPMI-1640 supplemented with fetal bovine serum + PBS and antibiotics (penicillin-streptomycin). Cells were enumerated in a hemocytometer and the suspension was adjusted to contain $2x10^6$ cells/ml. Fifty µl of this cell suspension ($2x10^5$ cells/ml) was aliquoted, in triplicate, in 96-well tissue culture plates. Fifty µL of the mitogen solution was then added. The volume in each well was adjusted to 200 µL by the addition of 100 µL of medium RPMI plus bovine serum. The concentration of mitogens used were phytohematogglutinin

(PHA) 5 μg/ml, Concanavalin A (Con A) 1 μg/ml, and recombinant human IL-2 10 U/ml; control cultures without mitogens were used as negative controls. The culture plates were incubated at 37°C in a 5% CO_2 in air, humidified incubator for 48 hours. Methyl-[$^3H_3$]-thymidine (1 μCi/culture) was added during the last 18 hours of incubation. Cultures were stored at -20°C prior to harvesting. Samples were harvested on filter paper using an automated cell harvester, and filters counted using a liquid scintillation counter to determine the incorporation of [^3H]-thymidine into peripheral blood leukocytes.

Milk samples were prepared for analysis using the procedures described for forages by Fick et al. (1979). Calcium, Mg, K, Na, Cu and Zn were determined by atomic absorption spectrophotometry (Perkin-Elmer, 1980). Phosphorus and Se were determined as described previously for forages.

Liver biopsy samples were prepared and analyzed according to the method described by Fick et al. (1979). Copper, Zn, Fe and Mn concentrations were determined using a Perkin-Elmer AAS 5000 (Perkin-Elmer, 1980). Cobalt and Mo concentrations were determined as previously described for forages. Similarly, liver and hair selenium were determined by the procedures described before for forages.

Mineral Supplements

Mineral supplements used in the experiments were prepared and analyzed by the procedures described by Fick et al. (1979). Minerals analyzed and procedures used correspond to those described before for forage samples, except phosphorus, which was analyzed by the colorimetric method described by Harris and Popat, (1954).

Statistical Analysis

Serum, milk, hair and lymphocyte blastogenic response data were statistically analyzed using repeated-measures analysis of variance (Freund et al., 1986; Gill and Hafs, 1971; Milliken and Johnson, 1984) with the General Linear Models (GLM) procedure of the SAS System (SAS Institute Inc., 1987). Due to the unequal subclass numbers, least squares means were calculated for all response variables evaluated.

Gross correlations were performed for variables in the forage, soil, serum, liver, milk, as well as for selenium and vitamin E content in serum of cows and calves and for the selenium content of different tissues.

Experiment 3

This experiment was conducted at the Pine Acres Research Unit of the University located in Central Florida. Sixty-three 2 year old heifers were used in the experiment.

Heifers were Angus x Brahman and pure Brahman and all were identified according to the proportion of blood based on a 32/32 fraction of Angus and Brahman. For management purposes these fractions were coded into six groups as follows:

Group 1 Animals with 28/32 of Angus or higher.
Group 2 Animals between 21/32 - 27/32 of Angus.
Group 3 Only Brangus 20/32 (20/32 Angus and 12/32 Brahman).
Group 4 Animals between 12/32 - 19/32 of Angus.
Group 5 Animals between 4/32 - 11/32 of Angus.
Group 6 Pure Brahman.

This coding was also used for the statistical analysis. Animals from each of these groups were randomly assigned to the experimental groups which included a treatment combination consisting of three levels of selenium 0, 1.0 and 1.5 mg of Se/kg of live weight and two levels of vitamin E, 4.5 and 9.0 mg of α-tocopherol/kg of live weight. Both, Se and vitamin E were applied by intramuscular injection, and the sources were sodium selenite and dl-α-tocopherol, respectively. Treatments were given between one and two months before projected calving on December 18 and January 16, based on the records of palpation taken in July and September 1989.

Heifers were fed on a grass-legume silage diet before parturition. Molasses was provided ad libitum, and a free choice trace mineral salt. After parturition, they were fed on a corn silage diet and the free-choice trace mineral salt. Animals remained on pastures before and after calving and as a result they started the spring grazing in early March. The composition of the silages as well as the trace mineral mixture given during the experimental period are given in Table 2.

Sample Collection and Preparation

Blood samples from heifers were collected before the treatments were applied, at calving time and one and two months later. Blood samples from calves were taken at birth, one and two months later, simultaneously with colostrum and milk samples from their mothers. Prior to collecting the first drawn milk, cows received a one ml oxytocin injection to stimulate milk let down. Blood samples were centrifuged for 20 min. at 700 g and serum samples were stored temporarily in a freezer at Pine Acres along with the colostrum samples. They were then stored frozen in the Animal Nutrition laboratory in Gainesville until chemical analysis. Serum, colostrum and milk samples were analyzed by the procedures described before for milk and serum samples.

Experiment 4

This experiment was conducted with pregnant ewes in the Sheep Research Unit of the University of Florida testing the same treatment combinations, sources and doses used in

TABLE 2. MINERAL COMPOSITION OF SILAGE AND TRACE MINERAL SALT PROVIDED (EXPERIMENT 3)[a]

	Macro minerals (%)					
Material	Ca	P	K	Mg	Na	N
Corn silage	.27	.14	.84	.19	0.05	--
Grass silage	.72	.22	.85	.22	0.05	1.48
Salt	.37	.01	.60	.15	16.70	--
	Trace minerals (ppm)					
Material	Cu	Zn	Fe	Mn	Mo	Se
Corn silage	4	0.3	42	68	1.5	0.01
Grass silage	7	0.4	25	60	1.0	0.10
Salt	319	28.0	188	936	0.0	1.73

[a] Mean of two samples.

experiment 3. Twenty one native ewes, 2 to 3 years old were used for this experiment and were randomly assigned to each treatment combination. Treatments started one month before lambing on December 18 and January 2, 1991 according to the pregnancy stage of the ewe. The above levels of Se and vitamin E were split into two equal doses, and the second dose was given 10 days after the first dose. Before lambing, ewes grazed on Bermuda grass (Cynodon dactylon) pastures and received .45 kg/h/d of a feed supplement and Bermuda grass hay ad libitum. After lambing, animals were brought to pens and fed 1.1 kg/h/d of the feed supplement and Bermuda grass hay ad libitum (average of 0.8 kg of dry matter/d), with free access to fresh water and a trace mineral salt. The ingredients used for the feed supplement were: ground corn, 78.8%; soybean meal, 14.8%; alfalfa leaf meal, 4.9%; biofos, .5%; limestone, .5%; and common salt .5%. Mineral analysis of the hay, feed supplement and trace mineral salt are presented in Table 3.

Sample Collection and Preparation

Blood samples from ewes were collected by jugular puncture using 10 ml vacutainers at lambing, one and two months later. Blood samples from the lambs were collected by

TABLE 3. MINERAL COMPOSITION OF FEED SUPPLEMENT, HAY AND TRACE MINERAL SALT PROVIDED (EXPERIMENT 4)

	Macro minerals (%)					
Material	Ca	P	K	Mg	Na	N
Supplement	.42	.29	.5	.11	.2	--
Hay	.21	.10	.5	.08	.1	.86
Salt	.13	.01	2.0	.01	17.6	--

	Trace minerals (ppm)					
Material	Cu	Zn	Fe	Mn	Mo	Se
Supplement	4	0.3	16	14	.7	.15
Hay	3	0.2	30	92	.0	.17
Salt	301	1.4	143	1355	.0	.25

jugular puncture in 10 ml vacutainers, at birth, one and two months later, simultaneously with colostrum and milk samples from their mothers. Prior to collecting the first drawn milk sample, ewes received a one ml oxytocin injection to stimulate milk let down. Handling and processing of blood, colostrum and milk samples were done in a similar way to the previous experiment.

Statistical Analysis for Experiments 3 and 4

These experiments were analyzed, using a split plot model with the General Linear Models (GLM) procedures of the SAS System (SAS Institute Inc., 1987). Due to the unequal subclass numbers, least squares means were calculated for all response variables evaluated.

CHAPTER IV
SEASONAL VARIATION OF SOIL AND FORAGE MINERAL CONCENTRATIONS IN NORTH FLORIDA

Introduction

Mineral imbalances (deficiencies or excesses) in soils and forages have been associated with low reproductive rates and animal production among grazing ruminants in tropical regions (McDowell et al., 1983). Most subtropical Florida soils are acid, infertile and sandy (Fiskell et al., 1972). Kiatoko et al. (1982) reported deficiencies of P, Se and Zn in four soil regions of Florida, with seasonal occurrence of K, Mg, Na, Cu and Co deficiencies in some of those regions. Mineral composition of plants is affected by soil-plant factors, including pH, drainage, fertilization, forage species, forage maturity and interaction among minerals (Gomide, 1978; Reid and Horvath, 1980). Analysis of the forage can provide insights into the likely nutrient status of the animal; however, factors such as soil contamination, variation in availability of ingested minerals and selective grazing may limit the value of analyzed mineral concentrations. Chambliss and Sollenberger (1991) indicated that bahia grass (Paspalum notatum) pastures had a longer growing season in south than in north Florida. In south

Florida growth slows down in October, but some pastures are used up until mid-December, while in north Florida bahia grass pastures are generally grazed from April to November. They also indicated that the quality of this grass is adequate for mature cattle but not for growing animals, especially in July and August.

The objective of this study was to evaluate seasonal concentrations of minerals in soils and bahia grass pastures under grazing conditions over a two-year period in north Florida.

Materials and Methods

A two-year study was conducted in north Florida on two farms located near Bronson and Williston using bahia grass Paspalum notatum pastures. Crossbred beef cows ¼ to ½ Angus were randomly assigned to each of two pastures in both locations. Forage and soil samples were collected in June and October 1988, and in March, May, June, August and October 1989. Three to five composite soil and forage samples from each of the two pastures in each location were collected in each sampling date. Animals grazed during the experimental period at a stocking rate of 1.6 cows/ha. Soil samples were collected using a stainless steel sampling auger at a depth of 15 to 20 cm. Samples were collected in plastic bags, dried at 60°C for 48 hr and passed through a 2 mm sieve and sent to the IFAS extension soil testing lab for chemical analysis. Forage samples were collected randomly in each pasture, at the same time and place as the soil samples. Subsequently, these samples were packed into paper bags and dried at 60°C for 48 hr. Forage samples were then ground using a Wiley mill with a 1 mm stainless steel sieve. Ground forage samples were stored in plastic bags until analyzed. Soil samples were analyzed for pH, organic matter (OM), Ca, P, K, Mg, Na, Cu, Zn, Fe, Mn and Al by the procedures used by the IFAS Extension Soil Testing Lab at the University of Florida (Rhue and Kidder, 1983). Soil minerals were extracted using the Mechlich I extracting solution method (.05 N HCl + .25 H_2SO_4). Mineral concentrations were determined by the Inductive Argon Plasma (ICAP) Thermo Jarrel Ash, Model 9000, Franklin (Jarrel-Ash Division, 1982).

Forage samples were prepared and analyzed for mineral concentrations following the methods described by Fick et al. (1979). Calcium, Mg, K, Na, Fe, Mn, Cu and Zn concentrations were analyzed by atomic absorption spectrophotometry (Perkin-Elmer, 1980). Cobalt and Mo were analyzed by flameless atomic absorption spectrophotometry on a Perkin-Elmer 3030 graphite furnace with Zeeman background correction (Perkin-Elmer, 1984). Nitrogen and P concentration in forage were determined on a Technicon Auto Analyzer II, following the method described by Gallaher et al. (1975) and Technicon Industrial Systems (1978). Selenium analysis of both forages and soils was determined following a modification of the fluorometric procedure described by Whetter and Ullrey (1978).

Forage and soil data were analyzed statistically using a split plot model (Freund et al. 1986; Milliken and Johnson, 1984) with the General Linear Models (GLM) procedure of the SAS System (SAS Institute Inc., 1987).

The model used was the same for the two years, as follows:

$Y_{ijkl} = \mu + \alpha_i + \beta_{j(i)} + c_k + (\alpha c)_{ik} + (\beta c)_{jk(i)} + \epsilon_{ijk}$

where,

y_{ijk} = Response variable;

μ = overall mean;

α_i = Effect of the ith location;

$\beta_{j(i)}$ = Effect of the jth pasture within the ith location;

c_k = Effect of the kth month;

$(\alpha c)_{ik}$ = Effect of the interaction between the ith location and kth month;

$(\beta c)_{jk(i)}$ = Effect of the interaction between the jth pasture and kth month;

ϵ_{ijk} = Random error term.

The error term to test location was $\beta_{j(i)}$, while $(\beta c)_{jk(i)}$ was used as the error term to test month and the location by month interaction.

When month of sampling was significant in 1989 the response was analyzed using contrasts for seasonal grazing as follows: early grazing season (March and May) compared with main grazing season (average of June, August and October); and for the second contrast, main grazing season compared with late grazing season (October). Due to the unequal subclass numbers, least squares means were calculated for all response variables evaluated. Gross correlations were performed for variables in forages and soils.

Results and Discussion

Soil pH, Organic Matter and Minerals

The probability levels for the effects of the experimental variables (location and month) as well as their interaction effect are listed in Appendix Tables A.1 and A.2. Means of soil pH, OM and mineral concentrations are shown in Tables 4 and 5.

There was no effect ($P>.05$) of sampling month or location on the concentrations of soil Ca, P, Mg, Na and Cu for either year. Concentrations of K and Zn and pH were also not affected by month or location in 1988, as well as OM in 1989. Greater ($P<.05$) concentrations of soil Fe, Al and Se and lower ($P<.05$) concentration of Mn were found at the Bronson than the at Williston locations. In October, soil OM was lower ($P<.01$) at Williston than at Bronson, and also lower ($P<.01$) than in June at Bronson.

TABLE 4. SOIL pH, ORGANIC MATTER (OM) AND MACROMINERAL CONCENTRATIONS AS RELATED TO GRAZING SEASON IN NORTH FLORIDA[a]

Grazing	Response Variable						
Season[b]	pH	OM	Ca	P	Mg	K	Na
C.L.[c]	< 5.5	--	< 71	< 17	< 30	< 62	--
				1988			
Main	6.0[e]	.91[e]	201[e]	17.8[e]	18.8[e]	12.2[e]	7.4[e]
Late	6.4[e]	.72[f]	291[e]	26.1[e]	20.3[e]	10.0[e]	9.1[e]
S.E.[d]	.17	.02	77	11.7	5.9	.54	1.3
				1989			
Early	5.7	1.19	187	16.3	23.2	18.9	8.0
Main	5.4	1.29	184	15.0	25.5	16.6	6.6
Late	5.4	1.13	181	15.8	27.4	19.8	6.5
S.E.	.10	.08	17	1.4	3.0	.91	.72
Contrast[g]	.01	.54	.79	.43	.32	.18	.05
Contrast[h]	.66	.16	.90	.66	.61	.02	.97

[a] Least squares means (ppm, except for pH).

[b] Early (March-May 1989), Main (June-August) and Late (October).

[c] Critical level = Concentrations below which are low or considered deficient (Rhue and Kidder, 1983; Sanchez, 1981; Viets and Lindsay, 1983).

[d] S.E. = Standard error of least squares means.

[ef] Means within the same column having different superscript differ $P<.05$.

[g] P value for early (March-May) vs main + late grazing season in 1989.

[h] P value for main (June- August) vs late grazing season (October) in 1989.

TABLE 5. SOIL TRACE MINERAL CONCENTRATIONS AS RELATED TO GRAZING SEASON IN NORTH FLORIDA[a]

Grazing	Response Variable					
Season[b]	Cu	Zn	Fe	Mn	Al	Se
C.L.[c]	< .3	< 1	< 2.5	< 5	--	< .5
			1988			
Main	.31[e]	.54[e]	11.7[e]	5.9[e]	96[e]	.077[e]
Late	.41[e]	.59[e]	10.9[e]	3.3[e]	153[e]	.106[e]
S.E.[d]	.08	.07	1.3	.6	44	.007
			1989			
Early	.39	.75	12.6	6.6	108	.076
Main	.30	.99	11.1	9.7	91	.053
Late	.27	1.48	11.5	8.3	97	.116
S.E.	.12	.16	1.0	.81	5.2	.016
Contrast[f]	.40	.02	.12	.01	.02	.88
Contrast[g]	.83	.04	.92	.19	.35	.01

[a] Least squares means (ppm).

[b] Early (March-May 1989), Main (June-August) and Late October).

[c] Critical level = Concentrations below which are low or considered deficient (Cary et al.,1967; Rhue and Kidder, 1983; Viets and Lindsay, 1983).

[d] S.E. = Standard error of least squares means.

[e] No significant differences were found between main and late grazing season $P>.05$.

[f] P value for early (March-May) vs main + late grazing season in 1989.

[g] P value for main (June- August) vs late grazing season (October) in 1989.

Variations in pH and Zn content of the soil in 1989 were due to month of sampling. The pH was higher (P<.05) in the early grazing season than in the remainder of the year (5.7 vs 5.4). Soil Zn was lower (P<.05) in the early grazing season than during the rest of the year, but was higher (P<05) in the late (October) than in the main grazing season.

Variations in soil K, Mn, Al and Se were due to the interaction between location and month. Soil K was higher (P<.05) in the late than during the main grazing season at Bronson (11.1 vs 14.6 ppm). In Bronson, soil Al was higher (P<.01) in the early grazing season than during the rest of the year (142 vs 119 ppm); but was also higher (P<.05) in the late than in the main grazing season (113 vs 133 ppm). Soil Se was higher (P<.01) at Williston in the late than in the main grazing season (.052 vs .117 ppm). Manganese was lower (P<.01) at Williston in the early grazing season than during the rest of the year (6.6 vs 9.2 ppm).

Mean soil OM content ranged from .72 to 1.29% and was lower than the mean value of 3.8% reported by Espinoza et al. (1991b) in central Florida soils.

Sanchez (1981) indicated that some acidity problems are associated with pH levels lower than 5.5 concomitant with the presence of exchangeable Al in the soil. Consequently, many plants exhibit poor growth and low herbage production caused by excess soluble Mn, Fe and Al; but above pH 5.5, Ca, P and other minerals are adequate for pasture growth of most species. Mean pH ranged from 5.4 to 6.4, which is generally within or above the critical level of 5.5 suggested by Sanchez (1981).

Mean soil P ranged from 15 to 26 ppm, with 63% of the samples deficient (<17 ppm). From central Florida, Espinoza et al. (1991b) reported soil P concentrations ranging from 5 to 20 ppm and Merkel et al. (1990) reported a mean value of 67.9 ppm. Soil K content ranged from 10 to 20 ppm, and all samples were below the critical value of 62 ppm suggested by Rhue and Kidder (1983) for optimum plant growth. These concentrations are similar to the values reported by Merkel et al. (1990) with 40.5 ppm and Espinoza et al. (1991b) with 10 to 65 ppm.

Mean soil Se concentrations ranged from .053 to .116 ppm with higher values in the late grazing season in both years; however all soil samples were below the critical level of .5 ppm indicated by McDowell (1985d). Mean soil Zn concentrations ranged from .54 to 1.48 ppm with 72% of the samples below the critical level of 1 ppm suggested by Rhue and Kidder (1983).

Lower concentrations than the reported critical values (Rhue and Kidder, 1983; Viets and Lindsay, 1973) for other minerals showed the following percentages: Ca, 10; Mg, 76; Cu, 64; and Mn, 65.

Forage Mineral and Protein Concentrations

Probability levels for effects of experimental variables (location and month) as well as their interaction effect are listed in Appendix Table A.3 and A.4. Mean forage mineral and protein concentrations are shown in Tables 6 and 7.

Forage concentrations of Ca, Na, Fe, Co, Mo and protein in 1988 were not affected by season or location ($P>.05$). Higher ($P<.05$) forage concentrations of P, K, Cu and Zn were found during the main grazing season (June) than in the late grazing season (October). Variations in forage concentration of Mg and Se were due to location, with greater ($P<.05$) Mg concentrations at the Bronson location than at Williston (.31% vs .20%), and higher ($P<.05$) forage Se at Bronson (.08 vs .06 ppm). Variations in forage Mn content were due to the interaction between location and month ($P<.01$), with lower concentrations at Williston in October than in June (.43 vs .85 ppm), and also lower than at Bronson (1.01 vs .43 ppm).

In 1989 most of the variation in forage mineral concentration was related to seasons. Greater ($P<.05$) concentrations of Ca, K, Mg, Na, Cu, Zn and Co were found in the early than in the remainder of the grazing season (June-October). On the other hand, lower ($P<.05$) concentrations of forage K, Mg, Cu, Mn and Co were found in the late than in the main grazing season. Greater ($P<.01$) forage Se concentrations were found in the late than in the main

TABLE 6. FORAGE MACROMINERAL AND PROTEIN CONCENTRATIONS AS RELATED TO GRAZING SEASON IN NORTH FLORIDA[a]

Grazing	Response Variable					
Season[b]	Ca	P	K	Mg	Na	Protein
C.L.[c]	< .3	< .25	< .8	< .2	< .06	< 7
Season	1988					
Main	.68[e]	.20[e]	1.17[e]	.27[e]	.04[e]	11.6[e]
Late	.38[e]	.08[f]	.29[f]	.24[e]	.02[e]	6.0[e]
S.E.[d]	.08	.016	.05	.05	.005	1.53
	1989					
Early	.47	.18	1.11	.24	.035	12.3
Main	.33	.17	.95	.23	.021	6.5
Late	.45	.21	.31	.18	.021	7.0
S.E.	.02	.10	.09	.013	.002	.86
Contrast[g]	.01	.90	.01	.04	.01	.01
Contrast[h]	.01	.02	.01	.02	.96	.66

[a] Least squares means (%).

[b] Early (March-May), Main (June-August) and Late (October).

[c] Critical level = Concentrations below which are deficient (Minson and Milford, 1966; McDowell, 1985d), based on requirements for beef cattle (NRC, 1984).

[d] S.E. = Standard error of least square means.

[ef] Means within the same column having different superscript differ P<.05.

[g] P value for early (March-May) vs main + late grazing season in 1989.

[h] P value for main (June-August) vs late grazing season (October) in 1989.

TABLE 7. FORAGE TRACE MINERAL CONCENTRATIONS AS RELATED TO GRAZING SEASON IN NORTH FLORIDA[a]

Grazing	Response Variable						
Season[b]	Cu	Zn	Fe	Mn	Co	Mo	Se
C.L.[c]	< 8	< 30	< 50	< 40	< .1	> 6	< .2
			1988				
Main	5.9[e]	36.2[e]	174[e]	140[e]	.08[e]	.53[e]	.060[e]
Late	2.3[f]	14.8[f]	117[e]	80[f]	.03[e]	.33[e]	.078[e]
S.E.[d]	.41	.9	14	5	.01	.07	.009
			1989				
Early	5.9	22.6	115	151	.06	.28	.048
Main	5.5	16.6	55	126	.05	.62	.044
Late	3.2	16.3	122	73	.02	.23	.089
S.E.	.55	1.8	24	11.2	.004	.05	.006
Contrast[g]	.04	.01	.12	.01	.01	.01	.09
Contrast[h]	.01	.88	.06	.01	.01	.01	.01

[a] Least squares means (ppm).

[b] Early (March-May), Main (June-August) and Late (October).

[c] Critical level = Concentrations below which are low or considered deficient or excessive in the case of Mo (McDowell, 1985d), based on requirements for beef cattle (NRC, 1984).

[d] S.E. = Standard error of least squares means.

[ef] Means within the same column having different superscript differ P<.05.

[g] P value for early (March-May) vs main + late grazing season in 1989.

[h] P value for main (June-August) vs late grazing season (October) in 1989.

grazing season (.089 vs .044 ppm). Variations in forage protein concentrations were due to location, with higher (P<.05) protein concentrations at Bronson than at Williston (9.7 vs 8.2%), and also due to seasons, with higher (P<.01) concentrations in the early grazing season than the rest of the year (12.3 vs 6.7%). Forage Fe was similar (P>.05) for both locations and all seasons.

Variations in Mn and Mo concentrations of the forage in 1989 were due to the interaction between location and month of sampling. Higher (P<.01) forage Mn concentrations were found at Williston in the early grazing season than during the rest of the year (216 vs 86 ppm), but lower (P<.01) concentrations in the late than during the main grazing season (188 vs 69 ppm). Molybdenum concentrations of the forage at the Williston location were lower (P<.01) in the early grazing season than in the rest of the year (.19 vs .28 ppm), but higher (P<.05) in the main than in the late grazing season (.33 vs .17 ppm).

Mean forage P ranged from .08 to .21%, with 97% of the samples below the critical level of .25% suggested by McDowell (1985d). These concentrations are similar to the range of .17 to .19% P reported by Espinoza et al. (1991b) for forages in central Florida. Mean forage Na ranged from .02 to .04% with all the samples below the .06% requirement level suggested by McDowell (1985d). Similar concentrations were reported by Espinoza et al. (1991b) with a range of .03

to .04% and Merkel et al. (1990) with an average of .03% forage Na in Florida.

Mean forage Cu concentrations ranged from 2.3 to 5.9 ppm with 94% of the samples below the critical level (McDowell, 1985d) of 8 ppm. Similar values from Florida studies were reported by Espinoza et al. (1991c) with a range of 3.0 to 3.3 ppm and Merkel et al. (1990) with a mean of 4.4 ppm forage Cu. Mean Zn content of the forage ranged from 14.8 to 36.2 ppm with 76% of the samples below the critical level (McDowell, 1985d) of 30 ppm. Espinoza et al. (1991c) reported similar forage Zn concentrations of 18 to 19 ppm. Forage Co was also deficient, with 83% of the samples below the critical level (McDowell, 1985d) of .1 ppm. Mean forage Co ranged from .02 to .08 ppm and was similar to the values reported by Espinoza et al. (1991c) and Merkel et al. (1990). Mean Se content of the forage ranged from .044 to .089 ppm and all samples were below the critical level of .2 ppm indicated by McDowell (1985d). Espinoza et al. (1991c) reported Se forage means of .07 and Merkel et al. (1990) .05 ppm. Deficiencies of other minerals in individual forage samples expressed as percentage of the total were as follows: Ca, 4; K, 40; Mg, 39; Fe, 14 and Mn, 2. In addition to the mineral deficiencies, 40% of forage samples were below the critical level of 7% crude protein suggested by Milford and Minson (1966).

Although, acidity appeared not to be a problem in these soils (mean pH 5.7), mineral deficiencies observed in the soil samples were likewise expressed in low mineral concentrations of the forage samples, especially in P, Cu, Zn and Se.

Forage and Soil Correlations

Gross correlations of soils and forages are shown in Appendix Tables A.5 to A.7. Considering values of correlation coefficients (r) $\geq|.5|$, the correlation coefficients were as follows: for forage, P and Cu (r= .50), K and Cu (r= .58), K and Zn (r= .57) Na and protein (r = .51); Cu and protein (r = .50), Co and Zn (r= .53), Co and Mn (r = .53). For soils, Ca and Mg (r = .60); K and Mn (r = .53); Zn and Mn (r = .55). Forage Mn and soil Mn (r= .56). Other forage and soil correlations were as follows forage Ca and soil Ca (r= .03) forage P and soil P (r= .01), forage K and soil K (r= .22), forage Mg and soil Mg (r= .07), forage Se and soil Se (r= .16). This values are in agreement with other reports indicating that mineral correlations among soil, plant and animal tissue concentrations are low or nonexistent (McDowell et al., 1984).

Summary

A two year study was conducted in north Florida on two farms located near Bronson and Williston for beef cattle grazing bahia grass pastures. Soil concentrations of Ca, P, Mg, Na and Cu were similar for both locations and seasons for either year. At Bronson soil Se was higher than at Williston in 1988; but in 1989, soil Se at Williston was higher in the late than in the main grazing season. All soil samples analyzed were deficient in K and Se, but deficiencies of above 63% of samples were found for Mg, Zn, P, Cu and Mn. Acidity appeared not to be a problem in soil mineral availability, since mean pH was 5.5 and higher.

Forage concentrations of Ca, Na, Fe, Co, Mo and protein were similar for all seasons and locations during 1988; however, greater ($P<.05$) concentrations of P, K, Cu and Zn were found in June than in October. In 1989 forage concentrations of Ca, K, Na, Zn, Co, Mg and Cu were higher in the early grazing season (March-May) than during the rest of the year; however, concentrations of K, Mg, Cu, Mn and Co were higher in the main grazing season (June to August) than in the late grazing season. Forage protein was higher in the early grazing season (March-May) than during the rest of the year. Forage Se was higher at Bronson than at Williston in 1988, and in 1989 forage Se was higher in the late (October) than in the main grazing season (June-August). Mineral deficiencies were found in 76% or more of the forage samples were found for Cu, Zn and Co; with all samples being deficient in Na, P and Se. Consequently, grazing cattle at these locations need continued mineral supplementation of these elements to prevent deficiency diseases from occurring and to support optimum animal productivity.

CHAPTER V
SERUM SELENIUM AND VITAMIN E, AND SELENIUM CONCENTRATION IN LIVER, MILK AND HAIR AS AFFECTED BY SUPPLEMENTATION TO BEEF CATTLE

Introduction

Selenium and vitamin E are essential nutrients required for growth, reproduction, protection of body tissues and prevention of nutritional diseases (Jenkins and Hidiroglou, 1972; McDowell, 1991). Florida is one of the regions in the United States with low Se concentration in soils and plants; consequently, grazing cattle require Se supplementation for optimum health and performance. Ammerman et al. (1980) reported increased concentrations of Se in plasma, milk and liver of Se supplemented cows. Similarly, McDowell et al. (1990) reported higher serum Se concentrations of cows and their calves following Se supplementation. Also, Se concentrations in liver, milk and hair were higher in the Se treated cows.

When both Se and vitamin E are deficient particular deficiency signs may develop, some of which are responsive to either Se and/or vitamin E supplementation (Combs and Combs, 1986; McDowell, 1989; Sheffy and Schultz, 1979).

Several disease problems have been reported in north Florida in beef cattle grazing native pastures on sandy soils near the town of Bronson; however, at a different location on soils with a more clayey type of texture (Archer and Williston) the same problems were not in evidence. The disease problems included severe scours and pneumonia, as well as a disease condition resembling shipping fever in calves, and Heinz body anemia in cows.

Several attempts to solve those problems have been unsuccessful or uneconomical and as a result, a Se and vitamin E supplementation trial was conducted at the problem area (Bronson) and non-problem area (Williston).

The objective of this study was to evaluate the effect of supplemental Se and vitamin E fed to grazing beef cattle on serum concentrations of these nutrients and Se concentrations in liver, milk and hair.

Materials and Methods

Two experiments were conducted in north Florida on two farms located near Bronson and Williston, with commercial crossbred beef cows over 3 years of age. Cows were ¼ to ½ Angus, crossbred with Hereford, Charolais and Brahman. Animals grazed on bahia grass *Paspalum notatum* pastures throughout the experimental period and received a mineral supplement that contained monensin. Analysis of the free-choice mineral supplement provided to the control animals was: Ca, 15.7%; P, 6.3%; Mg, 2.0%; K, 0.3%; Na, 11.0%; Mn, 2400 ppm; Fe, 7300 ppm; Zn, 2640 ppm; Cu, 448 ppm; Co, 16.4 ppm; Mo, 10.8 ppm; and Se, 0.8 ppm.

Experiment 1. In June 1988 a group of 48 pregnant cows was randomly assigned to two treatments at each farm as follows: 1) Control (no supplemental Se) and 2) Supplemental Se. Selenium as sodium selenite was administered as part of the free-choice mineral supplement to provide 23 ppm Se for the Se treatment. The average consumption of the mineral supplement was 65 g/h/d and the Se consumption was 1.5 and .052 mg/h/d for the Se treated and control animals respectively. Forage Se ranged between .044 and .089 ppm.

Experiment 2. In March 1989 additional treatments with and without vitamin E were included in combination with each level of Se. A group of 80 pregnant cows was randomly assigned to the four treatments at each farm as follows: 1) Control (without supplemental Se or vitamin E), 2) vitamin E, 3) Se and 4) Se + vitamin E.

Vitamin E was administered in boluses of 20 g/cow in both March and June 1989. This commercial product provided 10,000 IU of α-tocopherol/animal at each time. The Se treated animals in Bronson also received Se as sodium selenate in the drinking water from March to July 10, 1989. The average consumption of the mineral supplement was 65 g/h/d. Combining Se from both the mineral supplement and water, the average Se consumption other than pasture was 2.1 and 1.5 mg/h/d for the Se treated groups in Bronson and in

Williston, respectively. The level of supplemental Se administered in both experiments was chosen to provide between 1.5 to 2 times the requirement for beef cattle NRC (1980).

For both experiments blood, hair, milk and liver from cows as well as blood from the calves were collected in June and October in experiment 1 (1988). Blood and hair from cows were collected three times in experiment 2 (1989), in March, June and October. Milk and liver from the cows and blood from the calves were collected in June and October. Blood samples for mineral analysis were taken by jugular puncture in two 15 ml vacutainers, and centrifuged at 700 g for 20 min. Hair samples were clipped from the flank and rib of the animal using electric clippers, stored in plastic bags, washed with a Se-free commercial shampoo, rinsed twice with acationic detergent and dried at 60°C for chemical analysis.

Liver biopsies were collected using the technique described by Fick et al. (1979). Liver samples were kept in plastic bags and stored frozen for subsequent analysis. Milk samples were collected in 125 ml nalgene bottles using the first drawn milk. All animals were sampled shortly after administration of one ml oxytocin injection to stimulate milk let down. Milk samples were stored frozen until chemical analysis. Serum samples were deproteinated with 10% trichloroacetic acid (TCA) and 1% lanthanum chloride ($LaCL_3$). Selenium concentrations in serum, liver, milk and hair samples were determined following a modification of the fluorometric procedure described by Whetter and Ullrey (1978).

Vitamin E in serum of cows and calves was analyzed as α-tocopherol by high pressure liquid chromatography (HPLC). A 500 μL serum sample was used for the analysis. Ethanol was added to precipitate the serum proteins and double extraction of α-tocopherol with isooctane was performed on all samples. Analysis of α-tocopherol followed the method of Cort et al. (1983) and was amended as follows. The HPLC used consisted of a Perkin-Elmer Series 4 Liquid Chromatograph, a Perkin-Elmer LS-4 Fluorescent Spectrophotometer with excitation at 290 nm and a slit setting of 10, a Perkin-Elmer ISS-100 Autosampler equipped with a 50 μL loop and a normal phase Lichrosorb SI60 (5 μm) column 25 cm X 4.0 mm i.d. (E Merk Hi Bar). Chromatographs were recorded and peak areas were determined by using a Perkin-Elmer LCI-100 integrator. The mobile phase was 5% (v/v) tetrahydrofuran (HPLC) in 95% isooctane (HPLC) with a flow rate of 1.0 ml/min. The injection volume was 50 μL. Quantifying α-tocopherol was by comparison of retention time and peak areas with D-α-tocopherol standard.

With the exception of liver, data obtained in this study were analyzed statistically using Repeated Measures Analysis of Variance (Freund et al., 1986; Milliken and

Johnson, 1984) with the General Linear Models (GLM) procedure of the SAS System (SAS Institute Inc., 1987).

The model used for experiment 1 is the following:

$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + c_{k(ij)} + \delta_l + (\alpha\delta)_{il} + (\beta\delta)_{jl} + (\alpha\beta\delta)_{ijl} + \epsilon_{ijkl}$

Where,

Y_{ijkl} = Response variable;

μ = overall mean;

α_i = Effect of the ith location;

β_j = Effect of the jth selenium level;

$(\alpha\beta)_{ij}$ = Effect of the interaction between the ith location and the jth selenium level;

$c_{k(ij)}$ = Effect of the kth cow within the ith location and the jth selenium level;

δ_l = Effect of the lth time of sampling;

$(\alpha\delta)_{il}$ = Effect of the interaction between the ith location and the lth time;

$(\beta\delta)_{jl}$ = Effect of the interaction between the ith selenium level and the lth time;

$(\alpha\beta\delta)_{ijl}$ = Effect of the interaction between the ith location, jth selenium level and lth time;

ϵ_{ijkl} = Random error term.

The error term to test location, Se and their interaction was $c_{k(ij)}$, and ϵ_{ijkl} was used to test time and the interactions with time.

The model used for experiment 2 is the following:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + c_k + (\alpha c)_{ik} + (\beta c)_{jk} + (\alpha\beta c)_{ijk} + \delta_{l(ijk)} + \tau_m + (\alpha\tau)_{im} + (\beta\tau)_{jm} + (\alpha\beta\tau)_{ijm} + (c\tau)_{km} + (\alpha c\tau)_{ikm} + (\beta c\tau)_{jkm} + (\alpha\beta c\tau)_{ijkm} + \epsilon_{ijklm}$$

Where,

Y_{ijklm} = Response variable;

μ = overall mean;

α_i = Effect of the ith location;

β_j = Effect of the jth selenium level;

$(\alpha\beta)_{ij}$ = Effect of the interaction between the ith location and the jth selenium level;

c_k = Effect of the kth vitamin E level;

$(\alpha c)_{ik}$ = Effect of the interaction between the ith location and the kth vitamin E level;

$(\beta c)_{jk}$ = Effect of the interaction between the jth selenium level and the kth vitamin E level;

$(\alpha\beta c)_{ijk}$ = Effect of the interaction between the ith location, the jth selenium level and the kth vitamin E level;

$\delta_{l(ijk)}$ = Effect of the lth cow within the ith location, jth selenium level and kth vitamin E level;

τ_m = Effect of the mth time of sampling;

$(\alpha\tau)_{im}$ = Effect of the interaction between the ith location and mth time;

$(\beta\tau)_{jm}$ = Effect of the interaction between the jth selenium level and mth time;

$(\alpha\beta\tau)_{ijm}$ = Effect of the interaction between the ith location, jth selenium level and mth time;

$(c\tau)_{km}$ = Effect of the interaction between the kth vitamin E level and mth time;

$(\alpha c\tau)_{ikm}$ = Effect of the interaction between the ith location, kth vitamin E level and mth time;

$(\beta c\tau)_{jkm}$ = Effect of the interaction between the jth selenium level, kth vitamin E level and mth time;

$(\alpha\beta c\tau)_{ijkm}$ = Effect of the interaction between the ith location, jth selenium level, kth vitamin E level and mth time;

ϵ_{ijklm} = Random error term.

The error term to test location, Se, vitamin E and their interaction was $\delta_{l(ijk)}$ and ϵ_{ijklm} was used to test time and the interactions with time.

Liver data were analyzed as a split plot model (Freund et al., 1986; Milliken and Johnson, 1984) with the General Linear Models (GLM) procedure of the SAS System (SAS Institute Inc., 1987). We started the analyses with full models, but as a result of many vacant cells repeated-measures analysis of variance could not be performed. Then the analyses were conducted on a sequential manner. When higher order interactions were nonsignificant they were removed from the models assuming that those interactions were negligible. Also, some nonsignificant first order interactions were removed from the models to get the best possible estimates of the effects being evaluated. It is important to keep in mind the consequencies of removing terms from the model as follows: means may be biased, the probability of making type II error increases and less significant differences will be declared because the error term is inflated. Due to the unequal subclass numbers, least squares means were calculated for all the variables analyzed. The final model used for experiment 1 was the following:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + c_{(kij)} + \delta_l + (\alpha\delta)_{il} + (\beta\delta)_{jl} + \epsilon_{ijkl}$$

where,

y_{ijkl} = Response variable;

μ = overall mean;

α_i = Effect of the ith location;

β_j = Effect of the jth selenium level;

$(\alpha\beta)_{ij}$ = Effect of the interaction between the ith location and jth selenium level;

$c_{(kij)}$ = Effect of the kth cow within the ith location and jth selenium level;

δ_l = Effect of the lth time;

$(\alpha\delta)_{il}$ = Effect of the interaction between the ith location and lth time;

$(\beta\delta)_{jl}$ = Effect of the interaction between the jth selenium level and lth time;

ϵ_{ijkl} = Random error term.

The error term to test location, Se and their interaction was $c_{k(ij)}$, and ϵ_{ijkl} was used to test time and the interactions with time.

The model used for liver analysis in experiment 2 was similar to the one used for the serum variables, except for the 4-way interaction which could not be fitted due to the presence of vacant cells.

Results and Discussion

Serum Selenium

Probability levels for the effects of experimental variables and their interactions are listed in Appendix Tables A.8., A.9. and A.10. Serum Se concentrations as related to Se and vitamin E treatments and sampling times for both cows and calves are shown in Table 8. Supplemental Se increased serum Se levels at the end of experiment 1 (1988). Serum Se concentrations of Se treated and control animals in June were similar ($P>.05$), but in October both cows and calves receiving supplemental Se had higher ($P<.01$) serum Se concentrations than the controls. Also there was variation in serum Se of calves due to location and month of sampling ($P<.01$). Calves at Bronson had higher ($P<.05$) serum Se concentrations than controls in June (.040 vs .021 ppm).

In experiment 2 (1989) Se treated cows had higher ($P<.01$) serum Se concentrations than Se untreated cows (.093 vs .071 ppm). Variations in serum Se were also due to the

TABLE 8. EFFECT OF SUPPLEMENTAL SELENIUM (Se) AND VITAMIN E (VE) ON SERUM SELENIUM CONCENTRATION OF COWS AND CALVES[a]

		Experiment 1[b]		Experiment 2[c]			
		Cows	Calves	Cows		Calves	
Month	Treat	--	--	+ VE	- VE	+ VE	- VE
March	+ Se	--	--	.114	.113	--	--
	S.E.[d]	--	--	.008	.009	--	--
	- Se	--	--	.092	.092	--	--
	S.E.	--	--	.008	.008	--	--
June	+ Se	.051[a]	.027[a]	.102	.090	.055	.051
	S.E.	.007	.005	.007	.007	.007	.010
	- Se	.052[a]	.033[a]	.074	.063	.045	.049
	S.E.	.007	.004	.006	.006	.006	.007
October	+ Se	.111[a]	.066[a]	.073	.068	.080	.061
	S.E.	.007	.005	.006	.006	.008	.011
	- Se	.060[b]	.039[b]	.050	.052	.059	.070
	S.E.	.007	.004	.005	.005	.006	.007

[a] Least squares means (ppm).

[b] Significant effects: for cows Se*M (P<.01); and for calves L*M, Se*M (P<.01); (L =location and M = month).

[c] Significant effects: for cows Se (P<.01) and L*M (P<.05); and for calves L*Se*VE*M (P<.05).

[d] Standard error of the least squares means.

location and month of sampling interaction. Cows at Bronson had higher (P<.05) serum Se in March and October than at Williston. Serum Se of calves was affected by the interaction among location, Se, vitamin E and month of sampling (P<.05). However, the analysis of variance performed by location showed that none of the effects were significant (P>.10) at Bronson, while at Williston there was no effect (P>.10) of Se or location on serum Se concentrations, but higher (P<.01) serum Se concentrations were recorded in October than in June (.083 vs .057 ppm). There was no effect (P>.05) of vitamin E on serum Se concentrations of cows. Mean serum Se concentrations ranged from .027 to .114 ppm, with 24% of the samples from calves in experiment 1 and 11% in experiment 2 below the critical level of .03 ppm suggested by McDowell and Conrad, (1977). These values are similar to the .07 ppm reported by Merkel et al. (1990) in Charolais cattle from northern Florida. Espinoza (1990) reported values of .02 to .04 ppm in calves in central Florida.

Serum Vitamin E

Serum vitamin E as related to Se and vitamin E treatments and sampling time for both cows and calves is shown in Table 9. Variations in vitamin E were due to the interactions between location with Se (P<.01) and month of sampling with location (P<.01) and with Se (P<.05). Serum

TABLE 9. EFFECT OF SUPPLEMENTAL SELENIUM (Se) AND VITAMIN E (VE) ON SERUM VITAMIN E CONCENTRATION OF COWS AND CALVES IN EXPERIMENT 2[a]

		COWS[b]			CALVES[c]	
Month	Treat.	+ VE	- VE	Mean	+ VE	- VE
March	+ Se	5.0	5.6	5.3[f]	--	--
	S.E.[d]	.3	.4			
	- Se	6.2	5.8	6.0[e]	--	--
	S.E.	.3	.3			
June	+ Se	6.7	6.9	6.8[f]	1.9[e]	1.6[e]
	S.E.	.5	.5		.5	.5
	- Se	7.9	7.8	7.9[e]	2.6[e]	2.5[e]
	S.E.	.4	.5		.3	.4
October	+ Se	7.4	8.0	7.7[e]	2.9[f]	3.8[ef]
	S.E.	.4	.5		.4	.4
	- Se	7.9	7.3	7.6[e]	4.3[e]	3.9[ef]
	S.E.	.4	.4		.3	.3

[a] Least squares means (μg/mL of α-tocopherol).
[b] Significant effects: L*Se, L*M ($P<.01$); Se*M ($P<.05$); (L = location, M = month).
[c] Significant effects: Se*VE*M, L*Se*M ($P<.05$).
[d] Standard error of the least squares means.
[ef] Means within the same month having different superscripts differ $P<.05$, for either cows or calves.

vitamin E concentrations of non-Se treated cows were higher ($P<.05$) than in Se treated cows in March and in June 1989. Selenium supplemented cows at Williston had higher serum vitamin E concentrations than at Bronson (7.6 vs 5.5 μg of α-tocopherol/ml); Also at Bronson, Se supplemented cows had lower ($P<.01$) serum vitamin E concentrations than cows without supplemental Se (5.5 vs 7.2 μg of α-tocopherol/ml). Calves from cows supplemented with vitamin E but not with Se had higher ($P<.01$) serum vitamin E than calves supplemented with both Se and vitamin E in October 4.3 vs 2.9 μg of α-tocopherol/ml). Mean serum vitamin E concentrations for all treatments ranged from 5 to 8 μg/ml of α-tocopherol for cows and 1.64 to 4.30 μg/ml of α-tocopherol for calves. Stuart, (1987), suggested the significance of α-tocopherol concentrations for beef cattle as follows: 4 μg/ml adequate, 1.5 to 3.0 μg/ml low and below 1.5 μg/ml of α-tocopherol deficient. According to this scale, all cows were adequate in serum vitamin E, while all calves were in the low status category (1.64 to 2.59 μg/ml of α-tocopherol) in June. This may be due to the fact that most calves were recently born at sampling time in June, so that the higher vitamin E concentrations observed in October may reflect a direct contribution of the pasture.

Liver Selenium

Probability levels for the effect of experimental variables and their interactions are listed in Appendix Table A.11. Liver Se concentrations as related to Se and vitamin E treatments are shown in Table 10. Liver Se concentrations were similar ($P>.05$) for both treated and control cows in experiment 1. Variations in liver Se were due to month of sampling ($P<.01$), with .53 and 1.43 ppm in June and October, respectively.

In experiment 2 selenium supplemented cows had higher ($P<.01$) liver Se than non supplemented cows (2.0 vs 1.4 ppm). Liver Se was higher ($P<.01$) in June than in October (2.16 vs 1.22 ppm). There was no effect of vitamin E ($P>.10$) on liver Se concentrations. Mean liver Se concentrations in both years were higher than 1 ppm, which is above the critical value of .25 ppm suggested by McDowell (1985d). In Northern Florida, McDowell et al. (1990) reported liver Se values ranging from .25 to .63 ppm and Espinoza et al. (1991) in central Florida reported concentrations of liver Se ranging from .38 to .62 ppm.

Milk Selenium

Probability levels for the effects of experimental variables and their interactions are listed in Appendix Table A.12. Milk Se concentrations as related to Se and vitamin E treatments and sampling time are shown in Table

TABLE 10. EFFECT OF SUPPLEMENTAL SELENIUM (Se) AND VITAMIN E ON LIVER SELENIUM CONCENTRATIONS[a]

	Experiment 1[b]	Experiment 2[c]		
Treatment	--	+ Vitamin E	- Vitamin E	Mean
+ Se	1.01[e]	2.05	1.95	2.00[e]
S.E.[d]	.21	.29	.19	
- Se	.95[e]	1.45	1.31	1.38[f]
S.E.	.20	.17	.17	

[a] Least squares means (ppm).
[b] Significant effects: M (P<.01); (M = month).
[c] Significant effects Se, M (P<.01).
[d] S.E. = Standard error of the least squares means.
[ef] Means within the same column having different superscript differ P<.01.

11. Variations in milk Se concentrations in experiment 1 were due to the interaction among Se, location and month (P<.05). In October Se supplemented cows at Bronson had higher (P<.01) milk Se concentrations than at Williston (.031 vs .017 ppm) and also higher (P<.01) than control cows (.031 vs .014 ppm).

Variations in milk Se in experiment 2 were due to the interactions between month with Se (P<.01) and with location (P<.01). In October, Se treated cows had higher (P<.01) milk Se concentrations than control cows (.016 vs .010 ppm). For both experiments, mean milk Se concentrations ranged from .009 to .024 ppm. These values are similar to the concentrations of .007 to .015 ppm reported by Merkel (1989) in Florida Charolais cattle. McDowell et al. (1990) and Maus et al. (1980) reported higher milk Se concentrations from Se supplemented animals; however, other investigators (Conrad and Moxon, 1979; Essick and Lisk, 1987) reported low increases in milk Se in response to supplemental Se. In the present study the Se response was not consistent, since in October Se supplemented cows had higher milk Se concentrations in experiment 2, but only in one location in experiment 1 the Se response was higher than the controls.

Hair Selenium

Probability levels for the effects of experimental variables and their interactions are listed in Appendix

TABLE 11. EFFECT OF SUPPLEMENTAL SELENIUM (Se) AND VITAMIN E (VE) ON MILK SELENIUM CONCENTRATIONS[a]

		Experiment 1[b]	Experiment 2[c]		
Month	Item	--	+ VE	- VE	Mean
June	+ Se	.014[e]	.015	.015	.015[e]
	S.E.[d]	.002	.001	.001	
	- Se	.014[e]	.014	.014	.016[e]
	S.E.	.002	.001	.001	
October	+ Se	.024[e]	.017	.017	.016[e]
	S.E.	.002	.001	.001	
	- Se	.014[f]	.009	.009	.010[f]
	S.E.	.002	.001	.001	

[a] Least squares means (ppm).

[b] Significant effects: L*Se*M ($P<.05$); (L = location, M =month.

[c] Significant effects Se*M, L*M ($P<.01$).

[d] Standard error of the least squares means.

[e,f] Means within the same month and column having different superscripts differ $P<.05$.

Table A.13. Hair Se concentrations as related to Se and vitamin E treatments and sampling time are shown in Table 12. Variations in hair Se content in experiment 1 were due to month of sampling and its interactions with Se treatment ($P<.05$) and with location ($P<.05$). Selenium supplemented cows had higher ($P<.05$) hair Se than non supplemented cows in October (.56 vs .46 ppm). The analysis of variance by month showed no differences due to location ($P>.10$). Variations in hair Se concentrations in experiment 2 were due to the interaction among Se, location and month of sampling ($P<.01$). Selenium treated cows at Bronson had higher ($P<.10$) hair Se than at Williston in June (1.25 vs .92 ppm), and also higher ($P<.10$) than control cows at Bronson (1.25 vs .86 ppm). There was no effect of vitamin E ($P>.10$) in hair Se concentrations. Hidiroglou et al. (1965) reported that cows with hair Se ranging from .06 to .25 ppm produced calves with WMD, while cows with hair Se higher than .25 ppm had normal calves. Accordingly, for both experiments none of the cows were Se deficient. Mean hair Se concentrations ranged from .46 to 1.11 ppm and were similar to the values ranging from .48 to .84 ppm reported by Espinoza (1990) in Central Florida. In a Se study in Florida, McDowell et al. (1990) also reported higher hair Se concentrations in Se supplemented beef cattle; however in the present study Se supplemented cows had higher hair Se than the non supplemented cows in the last sampling of

TABLE 12. EFFECT OF SUPPLEMENTAL SELENIUM (Se) AND VITAMIN E (VE) ON HAIR SELENIUM CONCENTRATION[a]

		Experiment1[b]	Experiment 2[c]	
Month	Treatment	--	+ VE	- VE
March	+ Se		.73	.69
	S.E.[d]		.04	.05
	- Se		.52	.49
	S.E.		.04	.04
June	+ Se	.54[e]	1.11	1.05
	S.E.	.03	.12	.14
	- Se	.58[e]	1.04	.93
	S.E.	.03	.11	.11
October	+ Se	.56[e]	.94	.93
	S.E.	.04	.07	.08
	- Se	.46[f]	.79	.79
	S.E.	.04	.06	.06

[a] Least squares means (ppm).
[b] Significant effects: Se*M, L*M ($P<.05$); (L = location, M = month).
[c] Significant effects: L*Se*M ($P<.01$).
[d] Standard error of the least squares means.
[ef] Means within the same month having different superscripts differ $P<.05$.

October in experiment 1, but not in experiment 2.

Tissue and Fluid Selenium Correlations

Gross correlations among tissues and fluids of cows and calves are shown in Appendix Table A.14. Considering values of correlation coefficients (r) $\geq |.5|$, the gross correlations found in the present study were lower than .50.

Summary

Two experiments one in 1988 and one in 1989, were conducted to evaluate the effects of supplemental Se and vitamin E on serum Se and vitamin E concentrations, as well as Se concentrations in liver, milk and hair of grazing beef cattle in north Florida.

Selenium treated cows had higher serum Se concentrations than the controls in experiment 2. However, for other variables the Se response depended on month of sampling. In experiment 1, higher Se concentrations than the controls were found in October for serum of cows and calves and hair; however, liver and milk Se concentrations were similar for treated and controls. Higher milk and liver Se concentrations in experiment 2 were recorded in October.

With the exception of calves from experiment 1 in June, all cows and calves were above the critical level of .03 ppm serum Se. All cows were above the critical level of .25 ppm liver Se in both experiments.

There was no effect of vitamin E on liver, milk, hair or serum Se concentrations of cows. Selenium treated cows had lower serum vitamin E concentrations in March and June than Se untreated cows; but Se supplemented cows at Williston had higher serum vitamin E concentrations than at Bronson. Calves from cows supplemented with vitamin E, but not with Se had higher serum vitamin E than calves from cows receiving both Se and vitamin E or the control calves in October.

Since cattle used in this study were all commercial type of animals, many of them could have originated from Se non deficient areas and/or have been fed supplemental Se prior to the study, so that the response to supplemental Se and vitamin E on tissue and fluid Se concentrations could have been masked by their initial Se status. This may be the case of cows in experiment 2 in which serum Se concentrations were higher at the beginning of the experiment than during the experimental period.

Further investigations may be required to evaluate the effects of Se and vitamin E supplementation on animals of known origin, especially those raised in Se deficient pastures without supplemental Se.

CHAPTER VI
MINERAL STATUS IN BEEF CATTLE, LIVE WEIGHT CHANGES AND IMMUNE RESPONSE AS RELATED TO SELENIUM AND VITAMIN E SUPPLEMENTATION

Introduction

In many areas of the world cattle production depends almost exclusively on forages to provide all required nutrients. Under these circumstances, animal productivity is often seriously limited due to deficiencies or imbalances of essential nutrients. Langlands (1987) indicated that tissues and blood are more reliable means of evaluating mineral status of grazing ruminants than forages due to soil contamination or variability in diet selection or availability of ingested nutrients. Underwood (1981) indicated that mineral concentrations of serum or tissues significantly or consistently higher or below the 'normal' concentrations or ranges provide suggestive but not conclusive evidence of dietary deficiency or excess of particular minerals. He also indicated that the choice of tissue or fluid for analysis depends upon the mineral element under investigation. Body condition score (BCS) or changes in body condition is an indicator more reliable in evaluating nutritional status than live weight or changes in live weight and as a result BCS is a useful technique in making management decisions (Kunkle and Sand, 1990).

Vitamin E and Se play important roles in the functioning of the immune system. Cell-mediated immunity and humoral immune response were higher in vitamin E supplemented calves (Reddy et al., 1986). Selenium supplementation enhanced antibody response in weaned beef calves fed a Se deficient diet (Swecker et al., 1986). Supplemental Se along with Vitamin E enhanced serum antibody response to Pasteurella hemolytica in steers new to the feed lot environment (Droke and Loerch, 1989). Also, improved disease resistance was reported in dairy cattle with Se and vitamin E supplementation (Smith et al., 1985).

Several disease problems were reported in beef cattle grazing native pastures on sandy soils near Bronson (FL.); however, at a different location on soils with a more clayey type of texture (Archer and Williston) the same problems have not been recorded. The disease problems included severe scours and pneumonia, as well as a disease condition resembling shipping fever in calves, and Heinz body anemia in cows.

The objectives of this study were to evaluate the mineral status of grazing beef cattle, changes in live weight and BCS as well as the immune responsiveness in terms of mitogen-driven blastogenic response as related to Se and vitamin E supplementation. Effects of supplemental Se and vitamin E on Se and vitamin E concentrations in tissues and fluids are reported in Chapter V. Similarly, mineral status as related to liver and milk concentrations are reported in Chapter VII.

Materials and Methods

Two experiments were conducted in north Florida on two farms located near Bronson and Williston, utilizing pregnant crossbred beef cows over 3 years of age. Cows were ¼ to ½ Angus, crossbred with Hereford, Charolais and Brahman. Calving season was from April to June. Animals grazed on bahia grass Paspalum notatum pastures throughout the experimental period and received a mineral supplement that contained monensin. Analysis of the free-choice mineral supplement provided to the control animals was: Ca, 15.7%; P, 6.3%; Mg, 2.0%; K, 0.3%; Na, 11.0%; Mn, 2400 ppm; Fe, 7300 ppm; Zn, 2640 ppm; Cu, 448 ppm; Co, 16.4 ppm; Mo, 10.8 ppm; and Se, 0.8 ppm.

Experiment 1. In June 1988 a group of 48 pregnant cows was randomly assigned to two treatments at each farm as follows: 1) Control (no supplemental Se) and 2) Supplemental Se. Selenium as sodium selenite was administered as part of the free-choice mineral supplement to provide 23 ppm Se. The average consumption of the mineral supplement was 65 g/h/d and the Se consumption was 1.5 and .052 mg/h/d for the Se treated and control animals, respectively.

Experiment 2. In March 1989 additional treatments with and without vitamin E were included in combination with each level of Se. A group of 80 pregnant cows was randomly assigned to the four treatments at each farm as follows: 1) Control (without supplemental Se or vitamin E), 2) Vitamin E, 3) Se and 4) Se + vitamin E.

Vitamin E was administered in boluses of 20 g/cow of a commercial product which provided 10,000 IU of α-tocopherol, administered, in March and June 1989. The Se treated animals at Bronson also received Se as sodium selenate in the drinking water from March to July 10, 1989. The average consumption of the mineral supplement was 65 g/h/d. Combining Se from both the mineral supplement and water, the average Se consumption, other than pasture would be 2.1 and 1.5 mg/h/d for the Se treated groups in Bronson and in Williston, respectively.

For both experiments, blood samples for mineral analysis were taken by jugular puncture in two 15 ml vacutainers. Cows and calves were sampled twice, in June and October of each year, and cows were sampled additionally in March 1989. These samples were centrifuged at 700 g for 20 min. and were processed and analyzed according to the procedures described by Fick et al. (1979). Serum samples were deproteinated with 10% trichloroacetic acid (TCA) and 1% lanthanum chloride ($LaCL_3$) and analyzed for mineral content according to procedures described by Fick et al.

(1979). Calcium, Mg, Cu, Zn and Fe were analyzed by atomic absorption spectrophotometry with a Perkin-Elmer 5000 (Perkin-Elmer, 1980). Phosphorus concentration was determined using a colorimetric procedure described by Harris and Popat (1954).

Blood samples for lymphocyte blastogenic response were obtained from the cows in March, June and October 1989, simultaneously with the blood samples for mineral analysis. These samples were collected by jugular puncture into 60 ml blood collection tubes using acid citrate as anticoagulant. After collection blood samples were placed in a cooler with ice and brought to the Immunology laboratory, where they were processed the following day. Blood samples were centrifuged at 700 g for 20 min. and white blood cells (WBC) were then harvested with a Pasteur pipette and mixed with phosphate-buffered saline (PBS) for a total volume of 10 ml. The WBC and the medium were then layered on 5 ml Ficoll/Hypaque and centrifuged at 700 g for 40 min. Lymphocytes sedimented at the interface between ficoll and medium were collected with a Pasteur pipette, washed twice with RPMI-1640 medium and then resuspended in RPMI-1640 supplemented with fetal bovine serum + PBS and antibiotics (penicillin-streptomycin). Cells were enumerated in a hemocytometer and the suspension was adjusted to contain $2x10^6$ cells/ml. Fifty μl of this cell suspension ($2x10^5$ cells/ml) was aliquoted, in triplicate, in 96-well tissue culture plates. Fifty μL of the mitogen solution was then added. The volume in each well was adjusted to 200 μL by the addition of 100 μL of medium RPMI plus bovine serum. The concentration of mitogens used were phytohematogglutinin (PHA) 5 μg/ml, Concanavalin A (Con A) 1 μg/ml, and recombinant human IL-2 10 U/ml; control cultures without mitogens were used as negative controls. The culture plates were incubated at 37°C in a 5% CO_2 in air, humidified incubator for 48 hours. Methyl-[$^3H_3$]-thymidine (1 μCi/culture) was added during the last 18 hours of incubation. Cultures were stored at -20°C prior to harvesting. Samples were harvested on filter paper using an automated cell harvester, and filters counted using a liquid scintillation counter to determine the incorporation of [^3H]-thymidine into peripheral blood leukocytes.

Lymphocyte stimulation index was calculated as the ratio of counts per minute (CPM) from mitogen stimulated leukocytes over the control (no mitogen) culture.

Live weight of cows and calves as well as BCS of cows was taken at each sampling time. Live weight changes of cows were calculated by difference between sampling dates as follows: March-June, June-October and March-October. Live weight changes of calves were calculated as average daily gain (ADG) for the June to October period. Body condition scores were evaluated based on a 1 to 10 scale (Kunkle and Sand, 1990).

Data obtained in these experiments were analyzed statistically using Repeated Measures Analysis of Variance (Freund et al., 1986; Gill and Hafs, 1971; Milliken and Johnson, 1984) with the General Linear Models (GLM) procedure of the SAS System (SAS Institute Inc., 1987). The models used are the same ones as previosly described in Chapter V for experiments 1 and 2. Due to the unequal subclass numbers, least squares means were calculated for all the response variables evaluated.

Results and Discussion

The probability levels for the effects of experimental variables and their interactions for the general analysis as well as sampling months for mineral status are listed in Appendix Tables A.15 to A.21 for both cows and calves. For some minerals in both experiments there were statistically significant interactions which we do not believe were true biological Se effects on serum mineral concentrations of those minerals; consequently, no further discussion will be done on that aspect.

Mineral Status of Cows and Calves in Experiment 1

Mean serum mineral concentrations of cows and calves as related to location and sampling month are shown in Table 13. With the exception of P and Cu, all serum mineral concentrations in cows presented seasonal variation. Higher

TABLE 13. MEAN SERUM MINERAL CONCENTRATIONS OF COWS AND CALVES AS RELATED TO LOCATION AND SAMPLING MONTH (EXPERIMENT 1)[a]

		COWS				CALVES				
		June		October		June		October		
Element	Location	Mean	S.E.	Mean	S.E.[b]	Mean	S.E.	Mean	S.E.	C.L.[c]
Ca, mg/dl	Bronson	6.73	.28	9.13	.17	8.86	.41	10.28	.18	8.0
	Williston	6.46	.29	8.70	.17	7.53	.44	9.55	.20	
	Mean	6.60^{f}		8.92^{e}		8.20^{f}		9.92^{e}		
P, mg/dl	Bronson	4.22	.29	3.43	.24	9.56	.26	6.51	.21	4.5
	Williston	3.99	.29	3.88	.24	8.23	.28	5.63	.23	
	Mean	4.11^{e}		3.66^{e}		8.90^{e}		6.07^{f}		
Mg, mg/dl	Bronson	2.16	.09	2.33	.05	2.06	.08	2.09	.04	2.0
	Williston	2.02	.09	2.20	.05	1.78	.09	2.07	.04	
	Mean	2.09^{f}		2.27^{e}		1.92^{f}		2.08^{e}		
Cu, ppm	Bronson	.69	.06	.71	.04	.82	.07	.65	.04	.65
	Williston	.66	.06	.68	.04	.60	.07	.54	.05	
	Mean	.68^{e}		.70^{e}		.71^{g}		.60^{h}		
Zn, ppm	Bronson	.70	.04	.98	.04	1.18	.05	1.06	.04	.6
	Williston	.73	.04	.92	.04	.92	.06	.96	.04	
	Mean	.71^{f}		.94^{e}		1.05^{e}		1.01^{e}		

TABLE 13. CONTINUED

		COWS				CALVES				
		June		October		June		October		
Element	Location	Mean	S.E.	Mean	S.E.[b]	Mean	S.E.	Mean	S.E.	C.L.[c]
Fe, ppm	Bronson	1.52	.10	.76	.08	1.62	.14	.85	.14	1.0
	Williston	1.35	.10	.55	.08	.85	.16	.77	.15	
	Mean	1.44[e]		.66[f]		1.24[e]		.81[f]		

[a] Least squares means of cows are based on 21 and 20 samples from Bronson and Williston on each month; and 20 and 17 samples of the calves, respectively.

[b] S.E. = Standard error of least squares means.

[c] C.L. = Critical level (McDowell, 1985d; McDowell, 1987; McDowell and Conrad, 1977; NCMN, 1973).

[ef] Means in the same row for each group of cattle having different superscripts differ P<.01.

[gf] Means in the same row for each group of cattle having different superscripts differ P<.05.

($P<.01$) serum concentrations of Ca, Mg and Zn, and lower ($P<.01$) Fe concentrations were found in October than in June. Serum mineral concentrations were similar for both locations ($P>.05$), except for Fe, cows at Bronson had higher ($P<.05$) serum Fe than at Williston.

Serum mineral concentrations of calves varied with locations and sampling months. Calves at Bronson had higher ($P<.01$) serum concentrations of Ca and P and higher ($P<.05$) Cu and Zn than at Williston. Only in June serum Mg and Fe of calves at Bronson were also higher than at Williston. Serum Ca of calves was higher ($P<.01$) in October, while serum P and Cu were higher ($P<.05$) in June than in October.

On the average, serum Ca of cows in June was below the critical value of 8 mg/dl suggested by McDowell (1985d). Also in June mean serum Ca of calves (7.5 mg/dl) was low at Williston. Serum Ca of both cows and calves ranged from 6.46 to 10.28 mg/dl with 49% of the samples from cows and 28% from calves below the above critical level of 8 mg/dl. Similar concentrations for cattle in central Florida were reported by Espinoza et al. (1991a). On the average, only cows were P deficient, which mean values ranged from 3.43 to 4.22 mg/dl with 74% of the samples below the critical level of 4.5 mg/dl suggested by McDowell (1985d). Similar concentrations were reported by Espinoza et al. (1991), with a range of 3.2 to 5.4 mg/dl. On the average, serum Mg concentrations of calves at Williston were low, and 24% of the samples from both cows and calves were below the critical level of 2.0 mg/dl suggested by the NCMN (1973). Similar concentrations were reported by Espinoza with a range of 1.7 to 2.3 mg/dl.

On the average only calves at Williston were Cu deficient, however, 30% of the samples from cows and 43% from calves were below the critical value of .65 ppm suggested by McDowell and Conrad (1977). Similar concentrations were reported by Espinoza et al. (1991a) with a range of .76 to 1.12 ppm and Merkel et al. (1990) with .59 ppm in Charolais cattle in Florida. Only 13% of the serum samples from cows were below the critical level of .6 -.8 ppm of serum Zn suggested by McDowell (1987). Similar concentrations were reported by Espinoza et al. (1991a) with a range of .44 to .97 ppm and Merkel et al. (1990) with .77 ppm. On the average serum Fe of cows and Bronson calves was adequate in June. However, 51% of the samples from cows and 46% from calves were below the critical level of 1 ppm suggested by McDowell (1985d).

Mineral Status of Cows and Calves in Experiment 2

Mean serum mineral concentrations of cows and calves as related to location and sampling month are shown in Tables 14 and 15, respectively. Serum concentrations of all minerals in cows varied simultaneously with locations and sampling month; with most of the variations found in

TABLE 14. MEAN SERUM MINERAL CONCENTRATIONS OF COWS AS RELATED TO LOCATION AND SAMPLING MONTH (EXPERIMENT 2)[a]

		March		June		October		
Element	Location	Mean	S.E.	Mean	S.E.	Mean	S.E.[b]	C.L.[c]
Ca, mg/dl	Bronson	8.29[e]	.07	8.23[g]	.11	11.87[f]	.14	8.0
	Williston	8.16[e]	.07	7.85[h]	.11	12.84[e]	.14	
P, mg/dl	Bronson	3.24[e]	.10	3.50[g]	.12	3.55[e]	.14	4.5
	Williston	3.52[e]	.10	3.17[h]	.12	3.88[e]	.14	
Mg, mg/dl	Bronson	2.00[f]	.04	1.84[e]	.04	1.85[f]	.03	2.0
	Williston	2.15[e]	.04	1.87[e]	.04	2.03[e]	.03	
Cu, ppm	Bronson	.92[e]	.03	.75[e]	.03	1.02[f]	.02	.65
	Williston	.91[e]	.03	.80[e]	.03	1.19[e]	.02	
Zn, ppm	Bronson	.62[e]	.03	.83[h]	.03	.58[e]	.02	.6
	Williston	.64[e]	.03	.92[g]	.03	.48[f]	.02	
Fe, ppm	Bronson	2.64[e]	.10	2.49[e]	.08	1.38[f]	.07	1.0
	Williston	2.58[e]	.10	2.69[e]	.09	1.89[e]	.07	

[a] Least squares means are based on 40 samples from Bronson and 39 from Williston on each month respectively.

[b] S.E. = Standard error of least squares means.

[c] C.L. = Critical level (McDowell, 1985d; McDowell, 1987; McDowell and Conrad, 1977; NCMN, 1973).

[ef] Means in the same month for each mineral having different superscripts differ P<.01.

[gh] Means in the same month for each mineral having different superscripts differ P<.05.

TABLE 15. MEAN SERUM MINERAL CONCENTRATIONS OF CALVES AS RELATED TO LOCATION AND SAMPLING MONTH (EXPERIMENT 2)[a]

		June		October		
Element	Location	Mean	S.E.[b]	Mean	S.E.	C.L.[c]
Ca, mg/dl	Bronson	11.47[e]	.11	14.01[g]	.12	8.0
	Williston	7.68[f]	.11	12.60[h]	.11	
P, mg/dl	Bronson	7.14[e]	.15	7.31[e]	.18	4.5
	Williston	6.31[e]	.14	7.02[e]	.17	
Mg, mg/dl	Bronson	1.95[e]	.04	2.06[e]	.03	2.0
	Williston	1.84[e]	.03	2.02[e]	.03	
Cu, ppm	Bronson	.31[f]	.03	.95[f]	.03	.65
	Williston	.72[e]	.03	1.05[e]	.02	
Zn, ppm	Bronson	1.32[g]	.05	.75[e]	.02	.6
	Williston	1.18[h]	.04	.75[e]	.02	
Fe, ppm	Bronson	1.83[f]	.14	2.87[e]	.08	1.0
	Williston	3.61[e]	.13	1.82[f]	.07	

[a] Least squares means of calves are based on 30 samples from Bronson and 33 from Williston on each month.

[b] S.E. = Standard error of least squares means.

[c] C.L. = Critical level (McDowell, 1985d; McDowell, 1987; McDowell and Conrad, 1977; NCMN, 1973).

[ef] Means in the same month for each mineral having different superscripts differ P<.01.

[gh] Means in the same month for each mineral having different superscripts differ P<.05.

October. Serum Ca concentrations at Bronson were higher (P<.05) in June but lower (P<.01) in October, than at Williston. At Williston cows had higher (P<.01) serum Mg than at Bronson in June and October, as well as higher serum Fe in October. Only in June serum P at Bronson was higher (P<.05) than at Williston. Concentrations of serum Zn at Williston were higher than at Bronson in June, but in October they were lower (P<.01).

Serum mineral concentrations of calves also varied as a function of the interaction between location and month, except for P and Mg. Higher (P<.01) serum concentrations of P and Mg were recorded in October than in June, regardless of the location. Serum Ca at Bronson was higher (P<.05) in both June and October than at Williston, but serum Cu was lower (P<.01) in both months at Bronson. Serum Zn at Bronson was higher (P<.05) only in June. Serum Fe at Williston was higher (P<.01) than at Bronson in June, but lower (P<.01) in October.

On the average, both cows and calves had low serum Ca concentrations in June at Williston, with 14% of the cows and 17% of the calves below the critical level of 8 mg/dl suggested by McDowell (1985d). Mean serum Ca concentrations ranged from 7.85 to 12.84 mg/dl for cows and 7.68 to 14.01 mg/dl for calves and were similar to the values reported by Espinoza et al. (1991a) with a range of 8.4 to 10.0 mg/dl. On the average, only cows were deficient in serum P with 86%

of the samples below the critical level of 4.5 mg/dl suggested by McDowell (1985d). Mean serum P concentrations ranged from 3.17 to 3.88 mg/dl in cows and 6.31 to 7.31 mg/dl in calves. Similar values for cows were reported by Espinoza et al. (1991a) with a range of 3.2 to 5.4 mg/dl. On the average, only in June were cows and calves low in serum Mg, and also at Bronson cows were low in October; however 38% of the samples from cows and 30% from the calves were below the critical level of 2.0 mg/dl suggested by the NCMN (1973).

On the average, only in June were calves deficient in serum Cu; but 10% of the samples from cows and 30% from calves were below the critical level of .65 ppm suggested by McDowell and Conrad (1977). Mean serum Cu ranged from .75 to 1.19 ppm in cows and .31 to 1.05 ppm in calves. These concentrations are similar to the values reported by Merkel et al. (1990) with .59 ppm and Espinoza et al. (1991a) with a range of .76 to 1.12 ppm. On the average only cows were low in serum Zn in October; however, 23% of the samples from cows and 7% from calves were below the critical level of .6 to .8 ppm suggested by McDowell (1987). Mean serum Zn ranged from .48 to .92 ppm in cows and .75 to 1.32 ppm in calves. These concentrations are similar to the values of .77 ppm reported by Merkel et al. (1990) and a range of .44 to .97 ppm reported by Espinoza et at al. (1991a). Serum Fe concentrations of cows and calves were all above the critical level of 1 ppm suggested by McDowell (1985d). Mean serum mineral concentrations lower than the critical levels were found more often in cows than in calves as follows: P in both experiments, Ca in June for experiment 1 and Mg in June of experiment 2. At Williston serum Zn was also lower than the critical levels in October in experiment 2. Serum Fe was lower than the critical value in October for both cows and calves in experiment 2. Serum Cu and Ca were lower in calves in June in experiment 2. The above information indicates that most of the mineral deficiencies recorded in these experiments were seasonal. With the exception of P, on the average, serum mineral status was relatively satisfactory as a result of providing the free-choice mineral supplement to all the animals, since several minerals were deficient in the forage.

Serum Mineral Correlations

Gross correlations of serum minerals are shown in Appendix Tables A.22 to A.25. Considering values of correlation coefficients (r) $\geq |.5|$, the gross correlations found were as follows: In experiment 1 for cows, serum Ca and Zn (r= .63); and for calves Ca and Mg (r= .71), Ca and Zn (r= .53), Zn and Fe (r= .54). In experiment 2 for cows, serum Ca and Cu (r= .51); Ca and Fe (r= .54); and for calves serum Cu and Zn (r= .58).

Lymphocyte Blastogenic Response

Probability levels for the effects of experimental variables and their interactions for the general analysis and by month are listed in Appendix Tables A.26 and A.27.

Lymphocyte blastogenic response as related to Se and vitamin E and month of sampling are shown in Table 16. Mitogenic response to PHA and Con A varied with month of sampling and the interaction between vitamin E and location. Vitamin E treated cows at Williston had lower blastogenic response with both PHA ($P<.05$) and Con A ($P<.01$) than vitamin E untreated cows. At Bronson vitamin E untreated cows Con A had lower response Bronson than at Williston. Variations in mitogenic response to IL-2 were due to vitamin E and the interactions between Se and month, and location and month. Vitamin E supplemented cows had lower ($P<.01$) response to IL-2 than non control cows (7.76 vs 9.68). Only in March did Se treated cows have higher ($P<.01$) response to IL-2 than Se untreated cows. Cows at Williston had lower ($P<.01$) mitogenic response to IL-2 in June, but higher ($P<.01$) in October than at Bronson. Reddy et al. (1987) reported higher lymphocyte blastogenic response to T and B-cell mitogens in dairy calves supplemented with vitamin E (125-500 IU/ animal) than control calves. Parenteral Se supplementation of lambs with barium selenate increased

TABLE 16. LYMPHOCYTE BLASTOGENIC RESPONSE WITH PHA, Con A AND IL-2 AS RELATED TO SELENIUM (Se), VITAMIN E (VE) AND MONTH OF SAMPLING[a]

		PHA		Con A		IL-2	
Month		+ VE	- VE	+ VE	- VE	+ VE	- VE
March	+ Se	39.95	36.73	60.40	68.72	21.29	24.65
	- Se	16.55	26.24	36.13	60.97	8.22	14.66
June	+ Se	35.57	35.83	45.49	42.95	8.15	7.69
	- Se	32.56	29.56	48.65	35.43	8.25	7.68
October	+ Se	43.43	58.14	57.67	98.13	4.51	5.08
	- Se	46.59	83.58	63.92	134.09	4.18	7.70
	S.E.[b]	.49	.50	.43	.45	.38	.40
	S.E.[c]	.49	.50	.43	.43	.40	.40
Significance		L*VE*, M**		L*VE*, M**		VE*, Se*M**, L*M**	

[a] Lymphocyte stimulation index with mitogens: Concanavalin A (Con A), Phytohemagglutinin (PHA) and human recombinant Interleukin-2 (IL-2).

[b] Standard error of least squares means for + Se.

[c] Standard error of least squares means for - Se.

** P<.01.

* P<.05.

response of blood lymphocytes to PHA and pokeweed mitogens in vitro, while plasma from untreated lambs consistently had lower response (Turner et al., 1985).

In this study, it appears that neither vitamin E nor Se had any effect on the lymphocyte blastogenic response with any of the mitogens evaluated. However this experiment was conducted under field conditions and certain factors which might have had some effect on the response were not measured or under direct control such as differences in nutritive value and amount of herbage available, as well as management of the animals. In the case of vitamin E, perhaps closer and more frequent sampling could provide better information on the effect of supplemental boluses or how often the boluses should be administered to the animals under field conditions. On the other hand the report of disease problems at the end of the experiment indicated four cases of scours at Bronson in early April with death in one case.

Live Weight Changes and Condition scores

Probability levels for the effects of experimental variables and their interactions for cows and calves are listed in Appendix Tables A.28 and A.29. Differences in cow live weight, at the beginning of the experiment (March) were due to locations and Se. Cows at Bronson were heavier ($P<.01$) than at Williston (404 vs 352 kg). Also, cows treated with Se had higher (P<.10) initial live weight than the controls (386 vs 370 kg).

Variations in live weight changes were due to the location by Se interaction (P<.01) in the March-June and June-October periods, but for the whole experiment (March-October) these changes were due to the location*Se*vitamin E interaction (P<.05). However, the analysis of variance performed by location showed no differences due to the Se*vitamin E interaction.

All cows lost weight in the March-June period, except control cows at Bronson which gained 4.5 kg; however, Se treated cows lost more weight (P<.05) than the controls (Table 17). Selenium treated cows at the Williston location gained 14 kg; while the control cows lost weight (P<.05), and also both treated as well as the control cows lost weight at the Bronson location.

For the whole experiment (March-October) Se treated cows lost more weight at Bronson than the controls; however, at Williston, the reverse was true with less weight loss in the Se treated cows. Higher loss of weight in the March-June period was expected since most of the cows calved during this period. The continuous loss of weight during the June-October period may reflect the effects of lower availability and nutritive value of the forage, since bahia grass quality is often low in July-September, becoming unpalatable and low in feeding value with increasing maturity (Chambliss and

TABLE 17. MEAN CHANGES IN LIVE WEIGHT AND CONDITION SCORES OF COWS AS RELATED TO LOCATIONS, SELENIUM AND PERIODS (EXPERIMENT 2)

Period		Bronson		Williston	
		Mean[a]	S.E.[b]	Mean	S.E.
		Weight changes			
March-June	+ Se	-51.5^{d}	4.9	-13.7^{d}	3.3
	- Se	5.4^{c}	4.7	-1.8^{c}	3.1
June-Oct.	+ Se	-12.4^{c}	4.4	14.3^{c}	4.1
	- Se	-13.3^{c}	4.3	-16.2^{d}	3.8
March-Oct.	+ Se	-64.0^{d}	5.3	-1.4^{c}	4.6
	- Se	-8.2^{c}	5.0	-17.9^{d}	4.2
		Condition score			
March	+ Se	4.2^{c}	.16	4.6^{c}	.17
	- Se	4.6^{c}	.15	4.7^{c}	.16
October	+ Se	5.1^{c}	.13	4.4^{d}	.13
	- Se	5.1^{c}	.12	5.0^{c}	.12

[a] Least squares means in kg of live weight.
[b] S.E. = Standard error of the least squares means.
[cd] Means within the same period or month having diferent superscript differ P<.01.

Sollenberger, 1991).

Body condition scores of cows at the beginning of the experiment (March) were similar (P>.05) for both locations and Se levels. They ranged from 4.2 to 4.7. In October Se treated cows at Williston had lower (P<.01) BCS than the controls (4.4 vs 5.0), while both Se treated and control cows at Bronson had 5.1. Despite the high loss of weight in some cows from March-October (Se treated cows at Bronson and controls at Williston), mean BCS of most treatments was better in October than in March, with 5.0 BCS or higher, which is a desirable BCS of productive beef cows under normal grazing management conditions (Kunkle and Sand, 1990.

Live weight of calves was similar in June (P>.05) for both locations (182 and 174 kg at Bronson and Williston, respectively). Selenium treated calves had higher (P<.05) ADG at Williston than the controls (Table 18), but no differences in ADG were found due to Se levels at Bronson. The higher ADG in the Se treated calves at Williston also coincides with the higher weight gains obtained by their mothers during that period (June-October), as compared to the control cows which lost weight.

Summary

Two experiments one in 1988 and one in 1989 were conducted to evaluate the mineral status of grazing cattle on two farms in north Florida. Lymphocyte blastogenic

TABLE 18. AVERAGE DAILY GAIN OF CALVES AS RELATED TO LOCATIONS AND SELENIUM (EXPERIMENT 2)[a]

	Bronson		Williston	
	Mean	S.E.[b]	Mean	S.E.
+ Se	750^c	46	849^c	36
- Se	812^c	35	760^d	32

[a] Least squares means in grams/d from June to October 1989.

[b] S.E. = Standard error of the least squares means.

[cd] Means within the same column having different superscripts differ P<.05.

response, live weight gain and body condition scores were also evaluated in experiment 2 as related to the supplemental Se and vitamin E provided in this experiment.

In experiment 1 serum mineral concentrations of cows presented monthly variations, while in calves mineral concentrations varied as a function of location and/or month of sampling. In experiment 2 serum mineral concentrations for both cows and calves varied simultaneously as a function of location and sampling month. Variations in serum concentrations were not consistent from year to year or from cows to their calves. With the exception of P for cows in both experiments, and based on the mean concentrations, serum mineral status of both cows and calves was considered generally adequate in both experiments which may be accounted for by the consumption of the free-choice mineral supplement provided to all animals, since soil and forage data (Chapter IV) showed several minerals to be low to deficient.

Neither Se nor vitamin E had any effect on lymphocyte blastogenic response with any of the mitogens evaluated; however, the health status of cattle was also satisfactory on both farms during the time the experiment was conducted. Cows lost weight from March to October, but BCS in October were slightly higher than in March. Selenium supplemented cows at Williston were the only cows gaining weight from June-October and their calves had higher ADG than controls.

CHAPTER VII
MINERAL CONCENTRATION IN LIVER AND MILK OF GRAZING BEEF CATTLE AS RELATED TO SEASON AND LOCATION

Introduction

Assessment of mineral status of grazing ruminants has been considered an important strategy to increase animal productivity, especially in tropical areas where mineral deficiencies or imbalances are commonly found. McDowell (1987) indicated that tissue mineral concentrations, or their functional forms must be maintained within narrow limits if growth, health and productivity of the animal are to be maintained. Underwood (1981) stated that liver is a very useful tissue to determine the animal status due to its storage capacity for certain trace minerals which can be easily sampled by biopsy techniques without sacrificing the animal. Furthermore, McDowell et al. (1983) indicated that liver is an excellent indicator of the animal status of Cu, Co, Mn and Se, so that subnormal concentrations are indicative of dietary deficiency.

Milk and milk products are important sources of nutrients for the human population in many countries. Underwood (1981) indicated that milk is a rich source of Ca, P, K, Cl and Zn. Milk yield is affected by low dietary levels of Ca, P, K, Na and Fe (Underwood, 1981); however, the concentration of these minerals in milk is little affected by dietary intake (Miller, 1979; Underwood, 1981).

The objective of this study was to evaluate the mineral status of grazing beef cows on the basis of mineral concentration in liver and milk. Treatment effects on Se concentrations in liver and milk are reported in Chapter V.

Materials and Methods

Two experiments were conducted in north Florida on two farms located in Bronson and Williston, with crossbred beef cows over 3 years of age. Cows were ¼ to ½ Angus, crossbred with Hereford, Charolais and Brahman. Animals grazed on Bahia grass *Paspalum notatum* pastures throughout the experimental period and received a mineral supplement combined with monensin. Analysis of the mineral supplement provided to the control animals was: Ca, 15.7%; P, 6.3%; Mg, 2.0%; K, 0.3%; Na, 11.0%; Mn, 2400 ppm; Fe, 7300 ppm; Zn, 2640 ppm; Cu, 448 ppm; Co, 16.4 ppm; Mo, 10.8 ppm; and Se, 0.8 ppm.

Experiment 1. In June 1988 a group of 48 pregnant cows was randomly assigned to two treatments at each farm as follows: 1) Control (no supplemental Se) and 2) supplemental Se. Selenium as sodium selenite was administered as part of the free-choice mineral supplement to provide 23 ppm Se. The average consumption of the feed supplement was 65 g/h/d and the Se consumption was 1.5 and .052 mg/h/d for the Se treated and control animals, respectively.

Experiment 2. In March 1989 additional treatments with and without vitamin E were included in combination with each level of Se. A group of 80 pregnant cows was randomly assigned to the four treatments at each farm as follows: 1) Control (without supplemental Se or vitamin E), 2) vitamin E, 3) Se and 4) Se + vitamin E.

Vitamin E was administered in boluses of 20 g/cow of a commercial product which provided 10,000 IU of α-tocopherol/cow, administered in March and June 1989. The average consumption of the feed supplement was 65 g/h/d during both years.

For both experiments liver and milk samples were collected in June and October. Liver biopsies were collected using the technique described by Fick et al. (1979). Liver samples were kept in plastic bags and stored frozen for subsequent analysis. Milk samples were collected in 125 ml nalgene bottles using the first drawn milk. All animals were sampled shortly after administration of one ml intramuscular oxytocin injection to stimulate milk let down. Milk samples were stored frozen until chemical analysis. Liver and milk samples were prepared and analyzed according to methods described by Fick et al. (1979). Liver samples were analyzed for Cu, Zn, Fe, Mn, Co and Mo; while milk was analyzed for Ca, P, K, Mg, Na, Cu and Zn. Calcium, Mg, K, Na, Cu, Zn, Fe

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and Mn concentrations were determined using a Perkin-Elmer AAS 5000 (Perkin-Elmer, 1980). Cobalt and Mo concentrations were analyzed by flameless atomic absorption spectrophotometry on a Perkin-Elmer 3030 graphite furnace with Zeeman background correction (Perkin-Elmer, 1984). Phosphorus concentrations were determined by the colorimetric procedure following the method described by Harris and Popat (1954).

Liver data were analyzed statistically using a split plot model (Freund et al., 1986; Milliken and Johnson, 1984) with the General Linear Models (GLM) procedure of the SAS System (SAS Institute Inc., 1987). The models used were the same previously described in chapter V for liver and milk in experiemts 1 and 2. Due to the unequal subclass numbers, least squares means were calculated for all the response variables evaluated. Milk data were analyzed statistically using Repeated Measures Analysis of Variance (Freund et al., 1986; Milliken and Johnson, 1984) with the General Linear Models (GLM) procedure of the SAS System (SAS Institute Inc., 1987).

Results and Discussion

Mineral Status in Liver

Probability levels for the effects of experimental variables and their interactions are listed in Appendix Table A.30 and A.31. For some minerals in both experiments there were statistically significant interactions, which we do not believe were true biological Se effects on liver concentrations of these minerals; consequently, no further discussion will be done on that aspect.

Mean liver mineral concentrations as related to location and sampling month are shown in Table 19 for both experiments. Liver mineral concentrations of Zn and Mn were similar ($P>.05$) for both locations and sampling months in both experiments. Likewise liver concentrations of Fe and Co in experiment 1 were similar ($P>.05$) for both locations and sampling months. Seasonal variations in liver Cu were found with higher ($P<.05$) concentrations in October than in June in both experiments. Cows at Williston had higher ($P<.05$) liver Cu than at Bronson in both experiments. Greater ($P<.05$) concentrations in liver Fe and Co were recorded in June than in October in experiment 2. Liver Mo concentrations at Williston were higher ($P<.05$) than at Bronson in experiment 1.

Evaluation of liver mineral content of individual samples for lower concentrations than the suggested critical concentrations indicated that 9% of the samples in experiment 1 and 41% in experiment 2 were low in Zn. However, mean values ranged from 85 to 118 ppm in both experiments and were above the critical level of 84 ppm suggested by McDowell (1985d). Similarly, 22% of the samples were deficient in Co in experiment 1, but none in experiment

TABLE 19. MEAN LIVER MINERAL CONCENTRATIONS AS RELATED TO LOCATION AND SAMPLING MONTH[a]

		Experiment 1				Experiment 2				
		June		October		June		October		
Element	Location	Mean	S.E.	Mean	S.E.[b]	Mean	S.E.	Mean	S.E.	C.L.[c]
Cu, ppm	Bronson	105	1.4	137	1.0	151	6.9	170	6.6	< 25
	Williston	128	.9	309	1.4	236	19.8	285	6.5	
	Mean	117[f]		223[e]		193[h]		227[g]		
Zn, ppm	Bronson	118	35.5	95	25.1	107	7.3	85	7.0	< 84
	Williston	91	23.2	134	35.4	88	21.1	85	6.9	
	Mean	105[e]		115[e]		97[e]		85[e]		
Fe, ppm	Bronson	271	122	267	86	611	111	359	107	< 180
	Williston	222	80	301	121	1013	321	255	104	
	Mean	246[e]		284[e]		812[g]		306[h]		
Mn, ppm	Bronson	10.8	.8	7.5	.5	12.2	4.1	18.7	3.9	< 6
	Williston	10.3	.5	9.2	.8	28.5	11.8	17.8	3.8	
	Mean	10.5[e]		8.4[e]		20.3[e]		18.3[e]		

TABLE 19. CONTINUED

		Experiment 1				Experiment 2				
		June		October		June		October		
Element	Location	Mean	S.E.	Mean	S.E.[b]	Mean	S.E.	Mean	S.E.	C.L.[c]
Co, ppm	Bronson	.13	.03	.12	.02	.37	.03	.17	.02	<.05
	Williston	.12	.02	.18	.03	.23	.07	.10	.02	
	Mean	.13[e]		.15[e]		.30[e]		.14[f]		
Mo, ppm	Bronson	2.4	2.3	2.3	1.6	2.0	.26	1.8	.23	> 4
	Williston	3.4	1.5	4.6	2.3	2.5	.74	2.0	.24	
	Mean	2.9[e]		3.4[e]		2.3[e]		1.9[e]		

[a] Least squares means are based on 4 and 6 samples from Bronson in June and October; 8 and 5 from Williston in experiment 1. In experiment 2: 16 from Bronson in each month and 10 and 17 from Williston in June and October, respectively.

[b] S.E. = Standard error of least squares means.

[c] C.L. = Critical level (McDowell, 1985d; McDowell, 1987).

[ef] Means in the same row for each group of cattle having different superscripts differ P<.01.

[gh] Means in the same row for each group of cattle having different superscripts differ P<.05.

2. In both experiments 30% of the samples had Mo levels higher than 4 ppm which is considered excessive (McDowell, 1985d), but on the average, liver Mo was within the expected range. For both experiments, liver Cu concentrations ranged from 105 to 309 ppm with all samples above the critical level of 25 ppm (McDowell, 1985d). Liver Cu is the best criterion for assessing the Cu status of cattle (NCMN, 1973). Later findings however would suggest that liver Zn may not be an accurate indicator of Zn status of cattle (McDowell, 1992).

Mean liver mineral concentrations by locations and sampling months were all above the critical levels suggested by McDowell (1985d; 1987), thus indicating that the free-choice mineral salt effectively improved the mineral status of these cattle, since forage samples were not adequate for several minerals (Chapter IV). Other researchers (Espinoza et al., 1991 and Merkel et al., 1990) reported similar liver mineral concentrations in studies with grazing beef cattle receiving free-choice mineral supplementation in Florida.

Mineral Status in Milk

Probability levels for the effects of experimental variables and their interactions are listed in Appendix Tables A.32 to A.34. For some minerals such as Ca and P in experiment 2 there were statistically significant interactions which we do not believe as true biological Se effects on milk concentrations of those minerals; consequently, no further discussion will be done on that aspect.

Milk concentrations of most minerals showed seasonal variations (Table 20). Milk concentrations of K and Zn were higher (P<.05) in June than in October in both experiments, although K concentrations in experiment 1 varied as a function of location and month, with higher (P<.01) levels at Bronson than at Williston in June (.22 vs .16%). At Bronson milk Zn concentrations in experiment 2 were consistently higher (P<.05) than at Williston (3.5 vs 2.9 ppm).

Overall means for both locations and sampling months, mean K concentration ranged from .145 to .215% with 35% of the samples in both experiments below the reference value of .15% suggested by Underwood (1981). Mean milk Zn concentrations ranged from 2.43 to 3.96 ppm with 83% and 74% of the samples from experiments 1 and 2, respectively below the reference value of 4 ppm presented by Underwood (1981). Milk Na concentrations were consistently higher (P<.01) in October than in June in both experiments; contrary to what Corbin and Whittier (1974) indicated that Na concentrations increased toward the end of lactation. Mean milk Na concentrations ranged from .037 to .045% with 76% of the samples from experiment 1 and 81% in experiment 2 below the reference value of .05% presented by Underwood (1981).

TABLE 20. MEAN MILK MINERAL CONCENTRATIONS AS RELATED TO LOCATION AND SAMPLING MONTH[a]

		Experiment 1				Experiment 2				
		June		October		June		October		
Element	Location	Mean	S.E.	Mean	S.E.[b]	Mean	S.E.	Mean	S.E.	R.V.[c]
Ca, %	Bronson	.105	.006	.110	.004	.120	.002	.082	.002	<.12
	Williston	.107	.006	.119	.003	.114	.002	.076	.002	
	Mean	.106[h]		.115[g]		.117[e]		.079[f]		
P, %	Bronson	.076	.002	.066	.002	.066	.001	.073	.001	<.10
	Williston	.076	.002	.068	.002	.069	.001	.072	.001	
	Mean	.076[e]		.067[f]		.068[f]		.073[e]		
K, %	Bronson	.215	.015	.159	.012	.171	.006	.154	.006	<.15
	Williston	.162	.014	.164	.011	.159	.006	.145	.006	
	Mean	.189[g]		.162[h]		.165[e]		.150[f]		
Mg, %	Bronson	.008	.0005	.010	.0004	.009	.0002	.008	.0002	<.01
	Williston	.008	.0005	.011	.0004	.008	.0002	.008	.0002	
	Mean	.008[f]		.010[e]		.008[e]		.008[e]		

TABLE 19. CONTINUED

		Experiment 1				Experiment 2				
		June		October		June		October		
Element	Location	Mean	S.E.	Mean	S.E.^{b}	Mean	S.E.	Mean	S.E.	C.L.^{c}
Co, ppm	Bronson	.13	.03	.12	.02	.37	.03	.17	.02	<.05
	Williston	.12	.02	.18	.03	.23	.07	.10	.02	
	Mean	.13^{e}		.15^{e}		.30^{e}		.14^{f}		
Mo, ppm	Bronson	2.4	2.3	2.3	1.6	2.0	.26	1.8	.23	> 4
	Williston	3.4	1.5	4.6	2.3	2.5	.74	2.0	.24	
	Mean	2.9^{e}		3.4^{e}		2.3^{e}		1.9^{e}		

[a] Least squares means are based on 4 and 6 samples from Bronson in June and October; 8 and 5 from Williston in experiment 1. In experiment 2: 16 from Bronson in each month and 10 and 17 from Williston in June and October, respectively.

[b] S.E. = Standard error of least squares means.

[c] C.L. = Critical level (McDowell, 1985d; McDowell, 1987).

[ef] Means in the same row for each group of cattle having different superscripts differ P<.01.

[gh] Means in the same row for each group of cattle having different superscripts differ P<.05.

Similar concentrations were reported by Merkel (1989) with a range of .036 to .042% in Charolais cattle.

Milk Ca concentrations were higher (P<.05) in October in experiment 1, but higher (P<.01) in June than in October in experiment 2. The opposite was true for P with higher (P<.01) concentrations in June in experiment 1, but higher (P<.01) concentrations in October than in June in experiment 2. Milk Ca concentrations ranged from .076 to .119% with 63% of the samples in experiment 1 and 30% in experiment 2 below the reference value of .12% presented by Underwood (1981). Similar values were reported by Salih et al. (1987) with .128% milk Ca in Brahman cows and Merkel (1989) with a range of .08 to .11% in Charolais cattle. Milk P concentrations ranged from .066 to .076% with 100% of the samples in both experiments below the reference value of .10% presented by Underwood (1981). These concentrations are similar to the values reported by Salih et al. (1987) with .090% and .07% in Florida cattle.

Milk Mg was higher (P<.01) in October than in June in experiment 1 with no differences in experiment 2; while the opposite was true for Cu, with higher (P<.01) milk Mg concentrations in June than in October in experiment 2. Milk Mg ranged from .008 to .011% with 44% of the samples from experiment 1 and 57% from experiment 2 below the reference value of .01% presented by Underwood (1981). Similar values were reported by Merkel (1989) with a range of .036 to .042% in Charolais cattle.

Milk Cu concentrations ranged from .148 to .723 ppm with 66% and 54% of the samples for experiments 1 and 2, respectively below the reference value of .2 ppm presented by Underwood (1981). These concentrations are similar to the values of .19 ppm reported by de Maria (1978), Salih et al. (1987) with .31 ppm and Merkel (1989) with a range of .29 to .31 ppm.

Although a high percentage of the milk samples were below the reference presented by Underwood (1981), the mean mineral concentrations found in the present study are similar to the values reported by Merkel (1989) and Salih et al. (1987) on mineral supplementation studies of grazing beef cattle in central Florida. It is also important to consider that some of the monthly differences in milk mineral concentrations among cows are likely related to the stage of lactation (Corbin and Whittier, 1974).

Mineral Correlations in Liver and Milk

Gross correlations of each liver and milk minerals are shown in Appendix Tables A.35 to A.389. Considering values of correlation coefficients (r) ≥ |.5|, the correlation coefficients were as follows: Liver Fe and Mn (r = .80); Co and Mn (r = .68) and Co and Mo (r = .59) in experiment 2. Milk correlations were Ca and Mg (r =.78) in experiment 1, and Cu and Zn (r =.54) in experiment 2.

Summary

Two experiments were conducted to evaluate the mineral status of grazing beef cows on the basis of mineral concentrations in liver and milk as affected by season and location in north Florida.

Liver Zn and Mn concentrations did not show seasonal or locational differences in either experiment, while Cu had seasonal variations with greater concentrations in October than in June. Mean liver mineral concentrations were adequate for all minerals evaluated. Milk concentrations of most minerals showed seasonal variations with K and Zn being consistently higher in June than in October. In both experiments, most milk samples had lower mineral concentrations than the reference values given by Underwood (1981) for cow's milk. The highest percentage of milk samples below the reference value in decreasing order were P, Na, Zn, Cu, Mg and Ca; however, with the exception of Zn and Cu which may be affected by low dietary levels, milk concentration of the other minerals is not considered to be affected by dietary intake of those minerals. Furthermore, liver Cu concentrations of all cows were adequate and liver is a good storage organ for Cu. These differences may in fact indicate that these reference values for cow's milk may be overestimated, since milk mineral concentrations from grazing cattle under mineral supplementation studies in central Florida reported similar concentrations for all the minerals evaluated in the present study. The overall mineral status of these cows based on liver and milk concentrations may be considered adequate mainly due to the supplemental free-choice mineral salt provided, since forage mineral concentrations of several minerals were low to deficient.

CHAPTER VIII
EFFECT OF PREPARTUM INJECTABLE SELENIUM AND VITAMIN E ON SERUM CONCENTRATIONS OF COWS AND EWES AND THEIR OFFSPRING, AND SELENIUM CONTENT OF MILK

Introduction

Transfer of nutrients to the offspring occurs via placental transfer and colostrum ingestion, with the amount of transferred nutrients depending upon maternal nutrient status and efficiency of transplacental and mammary transport mechanisms (Van Saun et al., 1989a). Dry matter intake of ruminants is usually low during the peripartum period, which results in low dietary consumption of Se and vitamin E. Therefore, supplementation of these nutrients at that time is sometimes required to prevent several deficiency diseases (Smith et al., 1988; Weiss et al., 1990). Selenium is readily transmitted through the placenta to the fetus, even in the presence of low maternal concentrations (Koller et al., 1984). Prepartum supplementation of the dam has increased calf serum Se at birth (Perry et al., 1978; Weiss et al., 1984; Kincaid and Hodson, 1989), and colostrum Se concentration (Campbell et al., 1990; Salih et al., 1987; Stowe et al., 1988). Some researchers have reported higher milk Se concentrations in Se supplemented cows (Maus et al., 1980; McDowell et al., 1990); however, very low responses have also been reported (Conrad and Moxon, 1979; Essick and Lisk, 1987). Supplemental Se increased Se concentration in ewe blood, lamb blood and ewe milk 8 weeks postpartum (Paulson et al., 1968). Paired maternal-fetal concentrations of α-tocopherol in bovine serum indicated inefficient placental transfer of vitamin E (Van Saun et al., 1989b). Similarly, Stowe et al. (1988) reported no beneficial effect of vitamin E supplementation of dams on serum α-tocopherol concentrations of their calves. Supplementing the ewe with α-tocopherol increased tocopherol in ewe plasma, but not in lamb plasma (Paulson et al., 1968). The level of Se causing illness or death varies within species. Caravaggi et al. (1970) reported 49% mortality in 2-4 week old lambs when sodium selenite was administered in a single intramuscular injection (.46 mg Se/kg live weight). Shortridge et al. (1971) reported acute Se poisoning of 6 month old calves with 67% mortality after administration of subcutaneous sodium selenite (.5 mg/kg live weight). Oral administration of 1.1 mg/kg Se as sodium selenite to mature cattle resulted in illness or death (Maag et al., 1960).

The objectives of this study were to evaluate 1) the effects of high single doses of injectable Se and vitamin E applied prepartum on serum Se and α-tocopherol content of cows and ewes and their offspring, as well as Se content in colostrum and milk, and 2) the relative duration or lasting effect of these nutrients in the animal's body and their offspring.

Materials and Methods

Two Se and vitamin E supplementation experiments were conducted in north Florida, one with beef cattle and the other with ewes.

Experiment 1. The cattle experiment was conducted at the Pine Acres Research Unit of the University of Florida using sixty-three pregnant crossbred Angus x Brahman heifers that were 2-3 years old. Breed groups were identified according to the proportion of blood based on a 32/32 fraction; with most animals ranging from 20/32 to 12/32 of Angus, and also pure Brahman cows (32/32). For management purposes these groups have been coded as follows:
Group 1: animals with 28/32 of Angus blood or higher.
Group 2: animals between 21/32 to 27/32 of Angus blood.
Group 3: only Brangus animals with 20/32 of Angus and 12/32 of Brahman.
Group 4: animals between 12/32 to 19/32 of Angus blood.
Group 5: animals between 4/32 to 11/32 of Angus.
Group 6: pure Brahman (32/32).

These codes were also used for the statistical analysis. Heifers from these groups were randomly assigned to the experimental groups which included treatment combinations of three levels of Se (0, 1.0 and 1.5 mg of

Se/kg of live weight) and two levels of vitamin E (4.5 and 9.0 mg of α-tocopherol/kg of live wight). Treatments applied were the following: 1) Control (without supplemental Se or vitamin E); 2) 4.5 mg α-tocopherol/kg; 3) 9.0 mg α-tocopherol/kg; 4) 1.0 mg Se/kg + 4.5 mg α-tocopherol/kg; 5) 1.0 mg Se/kg + 9.0 mg α-tocopherol/kg; 6) 1.5 mg Se/kg + 4.5 mg α-tocopherol/kg; and 7) 1.5 mg Se/kg + 9.0 mg α-tocopherol. Both Se as sodium selenite and vitamin E as dl-α-tocopherol were applied by intramuscular injections. Treatments were applied between one and two months prior to projected calving on December 18 and January 16, 1991, based on palpation records taken in July and September 1989. Animals remained on the frosted Bahia grass (_Paspalum notatum_ pastures and native species) throughout the experiment with access to free-choice mineral salt (without supplemental Se). Heifers were fed on a grass-legume silage diet with molasses provided ad libitum before parturition; but after parturition they were fed on a corn silage diet. Animals started the spring grazing in early March.

Experiment 2. This experiment was conducted at the Sheep Research Unit of the University of Florida with 21 pregnant ewes. Florida native ewes ranging from 2 to 3 years of age were randomly assigned to the seven experimental groups using the same levels, sources and treatment combinations as described for heifers in experiment 1. Treatments with both Se and vitamin E were applied one month prior to lambing either on December 18 or January 2, 1991, according to the pregnancy stage of the ewe. For this experiment the levels of Se and vitamin E were split into two equal doses, with the second dose given 8 to 10 days after the first dose. Before lambing ewes remained on bermuda grass (Cynodon dactylon) pastures and received .45 kg/h/d of a feed supplement and bermuda grass hay ad libitum. The feed supplement contained 78.8% ground corn, 14.8% soybean meal, 4.9% alfalfa leaf meal, .5% biofos, .5% limestone and .5% salt. After lambing animals were allocated in pens and fed 1.1 kg/h/d of the feed supplement and bermuda grass hay ad libitum (average of.8 kg DM/d) with free access to fresh water and a trace mineral salt. The Se content of the feeds provided were hay .17 ppm, feed supplement .15 ppm and the trace mineral salt .25 ppm. The average daily consumption of Se from these sources would be .2 ppm before lambing (not including the pasture contribution) and .3 ppm after lambing.

Blood samples from cows and ewes were collected prior to treatment administration, at parturition and one and two months after parturition. Blood samples from calves and lambs were taken at birth, and at one and two months of age, simultaneously with colostrum and milk samples from their mothers. Milk samples were collected in 125 ml nalgene bottles using the first drawn milk. Except at parturition, all animals were sampled shortly after administration of one ml oxytocin injection to stimulate milk let down. Blood samples were taken by jugular puncture in two 15 ml vacutainers from cows and calves and 10 ml vacutainers from ewes and lambs. These samples were centrifuged at 700 g for 20 min. Milk and serum samples were stored frozen until chemical analysis. Serum samples were deproteinated with 10% trichloroacetic acid (TCA) and 1% lanthanum chloride ($LaCl_3$). Selenium concentrations in serum and milk samples were determined following a modification of the fluorimetric procedure described by Whetter and Ullrey (1978). Serum vitamin E was analyzed as α-tocopherol by high pressure liquid chromatography (HPLC) as previously described in Chapter V.

Data obtained in this study were analyzed statistically using a split plot model (Freund et al., 1986; Milliken and Johnson, 1984) with the GLM procedure of the SAS System (SAS Institute Inc., 1987). Due to the unequal subclass numbers and many vacant cells the analyses were performed on a sequential manner. First, in experiment 3 all coded breed groups were not represented in all treatments, so that only groups 3, 4, and 6 were included in the analysis for cows; while in calves only groups 2, 3, 4, and 5 were included. Then, when higher order interactions were nonsignificant they were removed from the model assuming that those interactions were negligible. Also, some nonsignificant first order interactions were removed from the model to get the best possible estimates of the effects being evaluated, such as the breed group by Se and/or vitamin E interactions. In addition, the control treatment affected calculation of least squares means and as a result was deleted from the model, thus resulting in a straight two by three factorial combination of vitamin E and Se levels. The final model used for cows and calves was the following:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + c_k + \delta_{l(ijk)} + \tau_m + (\alpha\tau)_{im} + (\beta\tau)_{jm} + (c\tau)_{km} + \epsilon_{ijklm}$$

Where,

Y_{ijklm} = Response variable;

μ = overall mean;

α_i = Effect of the ith Se level;

β_j = Effect of the jth vitamin E level;

$(\alpha\beta)_{ij}$ = Effect of the interaction between the ith Se level and the jth vitamin E level;

c_k = Effect of the kth breed group;

$\delta_{l(ijk)}$ = Effect of the lth cow within the ith Se, jth vitamin E level and kth breed group;

τ_m = Effect of the mth period;

$(\alpha\tau)_{im}$ = Effect of the interaction between the ith Se level and mth period;

$(\beta\tau)_{jm}$ = Effect of the interaction between the jth vitamin E level and mth period;

$(c\tau)_{km}$ = Effect of the interaction between the kth breed group and mth period;

ϵ_{ijklm} = Random error term.

The error term to test Se, vitamin E and their interaction as well as breed group was $\delta_{l(ijk)l}$ and ϵ_{ijklm} was used to test period and the interactions with period.

For ewes the analyses was performed using a split plot model. The control treatment affected calculation of least squares means and as a result was deleted from the model, thus resulting in a straight two by three factorial combination of vitamin E and Se, respectively. The model used was the following:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + c_{k(ij)} + \delta_l + (\alpha\delta)_{il} + (\beta\delta)_{jl} + (\alpha\beta\delta)_{ijl} + \epsilon_{ijkl}$$

Where,

Y_{ijkl} = Response variable;

μ = overall mean;

α_i = Effect of the ith Se level;

β_j = Effect of the jth vitamin E level;

$(\alpha\beta)_{ij}$ = Effect of the interaction between the ith Se level and the jth vitamin E level;

$c_{k(ij)}$ = Effect of the kth ewe within the ith Se and jth vitamin E level;

δ_l = Effect of the lth period;

$(\alpha\delta)_{il}$ = Effect of the interaction between the ith Se level and lth period;

$(\beta\delta)_{jl}$ = Effect of the interaction between the ith vitamin E level and the lth period;

$(\alpha\beta\delta)_{ijl}$ = Effect of the interaction between the ith Se level, jth vitamin E level and lth period;

ϵ_{ijkl} = Random error term.

The error term to test Se, vitamin E and their interaction was $c_{k(ij)}$, and ϵ_{ijkl} was used to test period and the interactions with period.

The procedure used for the lambs analyses of data was similar to the one previously described for cows and calves. Both sexes were not represented in all the treatment combinations, and as a result there were many vacant cells. Also the interactions between sex with Se and/or vitamin E were nonsignificant (P>.05). In addition, the control treatment affected calculation of least squares means and as a result was deleted from the model, thus resulting in a straight two by three factorial combination of vitamin E and Se levels. The final model used for lambs was the following:

$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + c_k + \delta_{l(ijk)} + \tau_m + (\alpha\tau)_{im} + (\beta\tau)_{jm} + \epsilon_{ijklm}$

Where,

Y_{ijklm} = Response variable;

μ = overall mean;

α_i = Effect of the ith Se level;

β_j = Effect of the jth vitamin E level;

$(\alpha\beta)_{ij}$ = Effect of the interaction between the ith Se level and the jth vitamin E level;

c_k = Effect of the kth sex;

$\delta_{l(ijk)}$ = Effect of the lth lamb within the ith Se, jth vitamin E level and kth sex;

τ_m = Effect of the mth period;

$(\alpha\tau)_{im}$ = Effect of the interaction between the ith Se level and mth period;

$(\beta\tau)_{jm}$ = Effect of the interaction between the jth vitamin E level and mth period;

ϵ_{ijklm} = Random error term.

The error term to test Se, vitamin E and sex was $\delta_{l(ijk)l}$ and ϵ_{ijklm} was used to test period effects and the interactions with period.

Least squares means were calculated for all the response variables evaluated. To investigate the interactions with period, analyses of variance were done by period.

Results and Discussion

Experiment 1

Probability levels for the effects of experimental variables and their interactions for both cows and calves are listed in Appendix Table A.39. Milk Se concentrations varied as a function of the interaction between period with Se ($P<.05$) and with breed group ($P<.05$).

Selenium supplemented cows had higher $P<.05$ colostrum Se concentrations than control cows; however, there was no difference $P>.05$ in milk Se concentrations at one and two

TABLE 21. MEAN MILK SELENIUM (ppm) OF COWS AS RELATED TO SELENIUM, BREED GROUP AND PERIODS

	Colostrum		1 Month		2 Months	
Variable	Mean	S.E.[a]	Mean	S.E.	Mean	S.E.
Se (μg/kg)						
0	.043[d]	.011	.011[c]	.002	.010[c]	.001
1.0	.071[c]	.009	.016[c]	.002	.010[c]	.001
1.5	.077[c]	.009	.015[c]	.002	.011[c]	.001
Breed group[b]						
3	.081[c]	.012	.011[d]	.003	.007[d]	.001
4	.061[cd]	.009	.011[d]	.002	.009[d]	.001
6	.049[d]	.008	.020[c]	.002	.014[c]	.001

[a] S.E. = Standard error of the least squares means.

[b] 3 = Brangus (20/32 of Angus and 12/32 of Brahman); 4 = cows between 12/32 and 19/32 of Angus; and 6 = pure Brahman.

[cd] Means within the same column and variable having different superscript differ P<.05.

months (Table 21); thus indicating a short duration effect of Se supplementation in milk Se concentrations. Brangus cows had the highest colostrum Se concentrations, but were only higher (P<.05) than Brahman cows; however Brahman cows had higher (P<.05) milk Se concentrations at one and two months than the crossbred cows. The higher milk Se concentrations of Brahman cows may be due to differences in diet and sampling time, since these samples were collected in March and April (two months after the crossbred cows) when new herbage regrowth was available for grazing. There was no effect (P>.05) of vitamin E in milk Se concentrations.

Mean Se concentrations in the present study ranged from .043 to .077 ppm for colostrum and .010 to .015 ppm for milk and were slightly higher than the Se concentrations reported by Salih et al, (1987) with .032 ppm for colostrum and .007 ppm for milk. de Toledo et al. (1985) reported values of .041 to .046 ppm Se in colostrum from cows receiving prepartum injectable Se.

Serum Se concentrations varied with the supplemental Se. Selenium treated cows had higher (P<.05) serum Se concentrations than the control cows (.031 ppm for the controls vs .048 and .042 ppm for cows treated with 1.0 and 1.5 mg Se/kg live weight, respectively). Serum vitamin E concentrations of cows were similar (P>.05) for both levels of vitamin E (5.9 and 6.5 μg α-tocopherol/ml for the medium and high level of vitamin E treatments, respectively).

Variations in serum Se and vitamin E concentrations of cows were due to the interaction between period and breed group ($P<.05$). Brahman cows had lower ($P<.05$) serum Se concentrations in pre-treatment than the crossbred cows but higher ($P<.05$) than the control cows at two months (Table 22). Brangus cows had higher ($P<.05$) serum Se concentrations at parturition than the other breed groups.

Mean serum Se concentrations at parturition ranged from .048 to .070 ppm and were similar to the mean value of .058 ppm reported by Salih et al. (1987). For all periods, serum Se concentrations lower than the critical level of .03 ppm suggested by McDowell and Conrad (1977) were recorded for 29% of the samples.

There was no difference among breed groups in serum vitamin E concentrations ($P>.05$) at pre-treatment and parturition; however, Brahman cows had higher ($P<.01$) serum vitamin E concentrations at one and two months after parturition (Table 23). Fresh green forages are good sources of vitamin E, however vitamin E content is significantly reduced late in the growing season or in stored forages (McDowell, 1989; Smith et al., 1988). This may explain the higher serum vitamin E concentrations of Brahman cows since parturition and sample collecting times were different. Blood samples from crossbred cows for the one and two month

TABLE 22. MEAN SERUM SELENIUM (ppm) OF COWS AS RELATED TO BREED GROUP AND PERIODS

Breed	Pre-treat.		Calving		1 Month		2 Months	
group[a]	Mean	S.E.[b]	Mean	S.E.	Mean	S.E.	Mean	S.E.
3	.039[c]	.009	.070[c]	.008	.036[c]	.006	.035[d]	.006
4	.046[c]	.007	.050[d]	.006	.034[c]	.005	.026[d]	.004
6	.025[d]	.006	.048[d]	.006	.037[c]	.005	.043[c]	.005

[a] 3 = Brangus (20/32 of Angus and 12/32 of Brahman); 4 = cows between 12/32 and 19/32 of Angus; and 6 = pure Brahman.

[b] S.E. = Standard error of the least squares means.

[cd] Means within the same column having different superscript differ P<.05.

TABLE 23. MEAN SERUM VITAMIN E (μg/mL) OF COWS AS RELATED TO BREED GROUP AND PERIODS

Breed	Pre-treat.		Calving		1 Month		2 Months	
group[a]	Mean	S.E.[b]	Mean	S.E.	Mean	S.E.	Mean	S.E.
3	6.5[c]	.81	5.5[c]	1.00	3.7[d]	.72	4.1[d]	.83
4	7.2[c]	.62	5.3[c]	.77	4.9[d]	.59	5.8[d]	.58
6	7.9[c]	.54	5.3[c]	.68	7.9[c]	.56	11.4[c]	.64

[a] 3 = Brangus (20/32 of Angus and 12/32 of Brahman); 4 = cows between 12/32 and 19/32 of Angus; and 6 = pure Brahman.

[b] S.E. = Standard error of the least squares means.

[cd] Means within the same column having different superscript differ P<.05.

sampling were collected in January and February, while most Brahman cows and their calves were sampled in March and April, and all animals resumed the early spring grazing in March. Mean serum vitamin E concentrations ranged from 3.7 to 11.4 μg α-tocopherol/ml with 21% of the samples ranging from 1.5 to 3.0 μg/ml which is considered low for beef cattle (Stuart, 1987).

There was no effect of Se and/or vitamin E ($P>.05$) on serum Se concentrations of calves. Serum Se concentrations of calves were lower ($P<.10$) at two months than at birth or one month of age (Table 24). Mean serum Se concentrations in the present study ranged from .027 to .049 ppm with 25% of the samples below the critical level of.03 ppm suggested by McDowell and Conrad (1977). Similar concentrations were reported by McDowell et al. (1990) from calves in north Florida, with a range of .030 to .049 ppm.

Serum vitamin E concentrations of calves varied as a function of Se ($P<.05$) and periods ($P<.01$). Serum vitamin E concentrations of calves from the control cows were higher ($P<.05$) than in calves from cows treated with 1.0 mg Se/kg live weight (Table 25). The lowest serum vitamin E concentrations were found at birth (.95 μg α-tocopherol/ml), and the highest at two months of age (2.8 μg α-tocopherol/ml). These low serum vitamin E concentrations at birth are in agreement with the reports from Van Saun et al. (1989b) indicating inefficient placental transfer of vitamin

TABLE 24. MEAN SERUM SELENIUM (ppm) OF CALVES AS RELATED TO SELENIUM AND PERIODS

	At birth		1 Month		2 Months	
Selenium	Mean	S.E.[a]	Mean	S.E.	Mean	S.E.
0	.034[b]	.005	.049[b]	.008	.028[b]	.006
1.0	.046[b]	.006	.044[b]	.009	.037[b]	.007
1.5	.047[b]	.006	.038[b]	.009	.027[b]	.007
Mean	.042[c]		.044[c]		.031[d]	

[a] S.E. = Standard error of the least squares means.

[b] No significant differences within periods were found among Se levels P>.05.

[cd] Means within the same row having different superscript differ P<.10.

TABLE 25. MEAN SERUM VITAMIN E ($\mu g/mL$) OF CALVES AS RELATED TO SELENIUM AND PERIODS

Se	At birth		1 Month		2 Months		Se
mg/kg	Mean	S.E.[a]	Mean	S.E.	Mean	S.E.	Mean
0	1.06[b]	.26	1.50[b]	.21	3.54[b]	.43	2.00[d]
1.0	.78[b]	.31	1.48[b]	.24	1.89[c]	.53	1.38[e]
1.5	.97[b]	.31	1.82[b]	.24	2.38[bc]	.49	1.75[de]
Mean	.94[h]		1.60[g]		2.60[f]		

[a] S.E. = Standard error of the least squares means.

[bc] Means within the same column having different superscripts differ P>.05.

[de] Means for the overall Se effects having different superscripts differ P<.05.

[fgh] Means for the overall period effects having cifferent superscripts differ P<.05.

E. Furthermore, the higher levels found at one and two months, more likely reflected transfer from colostrum (Van Saun et al., 1989a) and milk, and also a direct contribution from the pasture (McDowell, 1989) with the spring grazing. According to Stuart (1987) 41% of the serum samples from calves were in the low category (1.5 to 3.0 μg α-tocopherol/ml, and 50% were deficient (<1.5 μg α-tocopherol/ml).

Experiment 2

Probability levels for the effect of experimental variables and their interactions for both ewes and lambs are listed in Appendix Table A.40. Variations in milk Se of ewes were due to the interaction between period with Se (P<.01) and with vitamin E (P<.05).

Selenium treated ewes had higher (P<.05) colostrum Se concentrations than controls (Table 26). One month after parturition ewes treated with 1.5 mg Se/kg live weight still had higher (P<.05) milk Se concentrations than control ewes, thus showing a longer effect of the high Se dose in the ewes than in the cows. Ewes receiving 9.0 mg α-tocopherol/kg live weight had lower (P<.05) colostrum Se concentrations than ewes receiving 4.5 mg α-tocopherol/kg live weight; but this effect was not found in milk at one or two months.

Mean colostrum Se concentrations in the present study ranged from .035 to .198 ppm and milk Se concentrations from

TABLE 26. MEAN MILK SELENIUM CONCENTRATIONS (ppm) OF EWES AS RELATED TO SELENIUM, VITAMIN E AND PERIODS

		Colostrum		1 Month		2 Months	
Variable	Level	Mean	S.E.[a]	Mean	S.E.	Mean	S.E.
Selenium	0	.035[c]	.025	.016[c]	.002	.018[b]	.002
	1.0	.180[b]	.031	.023[bc]	.003	.022[b]	.003
	1.5	.198[b]	.023	.027[b]	.002	.018[b]	.002
Vitamin E	4.5	.170[b]	.024	.021[b]	.002	.019[b]	.002
	9.0	.105[c]	.019	.023[b]	.002	.021[b]	.002

[a] S.E. = Standard error of the least squares means.

[bc] Means within the same column and variable having different superscript differ P>.05.

.016 to .027 ppm. Similar concentrations were reported by Norton and McCarthy (1986) for colostrum Se with a range of .104 to .118 ppm and for milk Se, 18 days after parturition with a range of .036 to .046 ppm. Paulson et al. (1968) reported Se concentrations ranging from .009 to .104 ppm in ewe's milk. All milk samples in the present study were above the reference value of .01 ppm Se suggested by Underwood (1981) for cow's milk.

Serum Se and vitamin E concentrations of ewes were not affected ($P>.05$) by Se or vitamin E treatments, and the main source of variation was period. Serum Se concentrations were lower ($P<.01$) at pre-treatment than after treatment (Table 27). Serum Se concentrations after treatment were all similar ($P>.05$). Norton and McCarthy (1986) reported similar plasma Se concentrations at parturition, with a range of .099 to .128 ppm following a prepartum vitamin E-Se injection of the ewes. In the present study 10% of the samples were below the level of .03 ppm Se suggested as critical for cattle (McDowell and Conrad, 1977).

Serum vitamin E concentrations of ewes were higher ($P<.01$) at pre-treatment than after treatment, and also higher ($P<.01$) than at one and two months later (Table 28). Mean serum vitamin E ranged from 4.6 μg α-tocopherol/ml before treatment to 1.9 μg α-tocopherol/ml after lambing. Only 6% of the samples were below 1.5 μg α-tocopherol/ml suggested as deficient for beef cattle (Stuart, 1987). This

TABLE 27. MEAN SERUM SELENIUM (ppm) OF EWES AS RELATED TO SELENIUM, VITAMIN E AND PERIODS

Selenium			Vitamin E		
mg/kg lwt.	Mean	S.E.[a]	mg/kg lwt.	Mean	S.E.
0	.062[b]	.010	4.5	.074[b]	.009
1.0	.075[b]	.012	9.0	.066[b]	.007
1.5	.074[b]	.009			

Period effect[c]

Contrast	Mean1	S.E.	Mean2	S.E.
Pre-treatment vs After	.036[e]	.009	.082[d]	.009
At parturition vs After	.095[d]	.009	.076[d]	.009
1 Month vs 2 Months	.084[d]	.009	.067[d]	.009

[a] S.E. Standard error of the least squares means.

[b] No significant differences were found within Se or vitamin E levels P>.05.

[c] Mean1 and Mean2 = Mean values for the comparison on each contrast.

[de] Means within the same row having different superscripts differ P<.01.

TABLE 28. MEAN SERUM VITAMIN E (μg/mL) OF EWES AS RELATED TO SELENIUM, VITAMIN E AND PERIODS

Selenium			Vitamin E		
mg/kg lwt.	Mean	S.E.[a]	mg/kg lwt.	Mean	S.E.
0	2.9[b]	.29	4.5	3.1[b]	.28
1.0	3.5[b]	.36	9.0	3.2[b]	.23
1.5	3.0[b]	.28			

Period effect

Contrast	Mean	S.E.	Mean	S.E.
Pre-treatment vs After	4.6[c]	.33	3.5[d]	.33
At parturition vs After	3.8[c]	.33	2.0[d]	.33
1 Month vs 2 Months	2.1[c]	.33	1.9[c]	.33

[a] S.E. Standard error of the least squares means.

[b] No significant differences were found within Se or vitamin E levels P>.05.

[cd] Means within the same row having different superscript differ P<.01.

consistent decrease in serum vitamin E concentrations from pre-treatment to two months after lambing may be due to animal body reserves stored during the grazing season, followed by a depletion of those reserves when animals depended only on hay and concentrates after lambing.

Serum Se concentrations of lambs were not affected by Se and/or vitamin E ($P>.05$). Likewise, serum Se concentrations of lambs were similar ($P>.05$) at all ages (Table 29). Mean serum Se concentrations in the preset study ranged from .057 to .105 ppm with 9% of the samples below the level of .03 ppm suggested as critical for cattle (McDowell and Conrad, 1977). Similar values for plasma Se were reported by Norton and McCarthy (1986) in an experiment with injectable Se and vitamin E, with a range of .080 to .109 ppm.

Serum vitamin E concentrations of lambs varied as a function of the interaction between vitamin E and period ($P<.01$). Serum vitamin E concentrations of lambs from ewes treated with 9 mg α-tocopherol/kg live weight were higher ($P<.01$) than in lambs from ewes treated with 4.5 mg α-tocopherol/kg live weight; but no differences ($P>.05$) were found at one or two months of age. Mean serum vitamin E concentrations of lambs in the present study ranged from 1.1 to 4.3 μg α-tocopherol/ml with 56% of the samples below the level of 1.5 μg α-tocopherol/ml suggested as deficient for beef cattle (Stuart, 1987).

TABLE 29. MEAN SERUM SELENIUM AND VITAMIN E OF LAMBS AS RELATED TO SELENIUM, VITAMIN E AND PERIODS

mg/kg lwt.	Birth	S.E.[a]	1 Month	S.E.	2 Month	S.E.
			SELENIUM (ppm)			
0	.076[b]	.027	.067[b]	.007	.071[b]	.027
1.0	.062[b]	.030	.088[b]	.007	.062[b]	.030
1.5	.057[b]	.022	.068[b]	.007	.105[b]	.022
			VITAMIN E (μg/mL)			
4.5	1.4[d]	.73	1.2[c]	.18	1.1[c]	.20
9.0	4.3[c]	.63	1.3[c]	.16	1.3[c]	.18

[a] S.E. = Standard error of the least squares means.

[b] No significant differences were found among Se levels within periods P>.05.

[cd] Means within the same colum having different superscript differ P<.05.

Summary

Two experiments were conducted to evaluate the effects of relatively high doses of supplemental Se and vitamin E injections to pregnant heifers and ewes on serum Se and α-tocopherol concentrations of the dam and their offspring, the Se concentration of colostrum and milk, and the relative duration of these nutrients in the animal body.

There was no effect of Se and vitamin E treatments on serum Se concentrations of ewes and lambs, and vitamin E concentrations of cows and ewes. Selenium supplementation increased the Se concentrations in serum of cows and colostrum of cows and ewes, with the response being higher in milk Se concentrations at one month in ewes treated with 1.5 mg Se/kg live weight.

Brahman cows had lower colostrum Se concentrations than crossbred cows, but higher milk Se concentrations at one and two months of age than crossbred cows. Similarly, serum Se concentrations of Brahman cows were lower at pre-treatment and parturition than the crossbred cows, but higher at two months. Likewise, serum vitamin E concentrations of Brahman cows were higher than the crossbred cows at one and two months. These higher Se and vitamin E concentrations of Brahman cows after parturition may reflect more availability of these nutrients in the pasture in March-April than in January-February, when most of the samples from the crossbred cows were collected.

Calves had lower serum Se concentrations at two months than at birth or one month of age; conversely, serum vitamin E concentrations were lower at birth than at one month and higher at two months than at one month, indicating inefficient placental transfer of vitamin E, but an important transfer from colostrum as well as a direct contribution from pasture during the early grazing in the spring.

Concentrations of serum Se were lower but serum vitamin E were higher for ewes at pre-treatment. Lambs from ewes treated with the high dose of vitamin E (9 mg α-tocopherol/kg) had higher serum vitamin E concentrations than with the low vitamin E dose.

The low responses to the Se and vitamin E applied in these two experiments may be due to the fact that the nutritional status of cows and ewes at treatment time was relatively adequate.

CHAPTER IX
SUMMARY AND CONCLUSIONS

Four experiments were conducted in north Florida to evaluate: 1) the effect of supplemental Se and vitamin E on serum concentrations of beef cattle and sheep and their offspring; 2) the Se concentrations in liver, milk and hair of cows, as well as the mineral status of the cattle from the first two experiments based on soil, forage, and animal tissue and fluid analysis.

In experiment 1, a group of commercial crossbred pregnant beef cows was randomly assigned to two treatments with and without Se in the mineral mixture at two locations (Bronson and Williston). Selenium as sodium selenite was added to the free-choice mineral salt to provide 23 ppm for the Se treated group. In experiment 2, two additional treatments with and without supplemental vitamin E were included in combination with each Se treatment at each location. Vitamin E was administered in boluses of 20 g/cow in both March and June 1989. This commercial product provided 10,000 IU of α-tocopherol per animal.

In experiment 1, soil, forage, liver and milk samples were collected in June and October. In experiment 2, forage and soil samples were collected in March, May, June, August and October. Blood and hair samples from cows were collected in March, June and October, while milk and liver from cows as well as serum samples from calves were collected in June and October.

Serum samples were analyzed for Ca, P, Mg, Cu, Zn, Fe, and Se; and in the second experiment vitamin E was also analyzed. Liver samples were analyzed for Cu, Zn, Fe, Mn, Co, Mo, and Se. Milk samples were analyzed for Ca, P, K, Mg, Na, Cu, Zn and Se. Forage samples were analyzed for Ca, P, K, Mg, Na, Cu, Zn, Fe, Mn, Co, Mo, Se and crude protein. Soil samples were analyzed for pH, OM, Ca, P, K, Mg, Na, Cu, Zn, Fe, Mn, Al and Se.

All soil samples were deficient in K and Se. Deficiency of the other soil minerals in decreasing order were the following: Mg, Zn, Mn, Cu and P. For most minerals, forage concentration had seasonal variation with higher concentrations of Ca, K, Na, Zn, Co, Mg and Cu during March-May than in the rest of the year. Lower concentrations of K, Mg, Cu, Mn and Co were found in the late grazing season (October) than in June- August. Protein content of the forage was higher in the early grazing season (March-May) than the rest of the year. The most deficient minerals in the forage were Se, Na, P, Cu, Co and Zn. Consequently, grazing cattle at these locations need continued mineral supplementation of these elements to prevent deficiency diseases from occurring and to support optimum animal productivity.

Selenium treated cows had higher serum Se concentrations than the controls in experiment 2, but milk and liver Se concentrations were higher than the controls only in October. Similarly, only in October were serum Se concentrations of cows and calves and hair of cows higher than the controls in experiment 1; however, liver and milk Se concentrations were similar for treated and controls. With the exception of calves from experiment 1 in June, all cows and calves were above the critical level of .03 ppm serum Se.

There was no effect of vitamin E on liver, milk, hair or serum Se concentrations of cows. Selenium untreated cows had higher serum vitamin E concentrations in March and June than Se treated cows; but Se supplemented cows at Williston had higher serum vitamin E concentrations than at Bronson. Calves from cows supplemented with vitamin E, but not with Se had higher serum vitamin E than calves from cows receiving both Se and vitamin E or the control calves in october.

Since cattle used in this study were all commercial type of animals, many of them could have originated from Se non deficient areas and/or have been fed supplemental Se, so that the response to supplemental Se and vitamin E on tissue and fluid Se concentrations could have been masked by their initial Se status.

Further investigation may be required to evaluate the effects of Se and vitamin E supplementation on animals of known origin, especially those raised in Se deficient pastures without supplemental Se.

Serum mineral concentrations of cows and calves varied with sampling month and locations. Similarly, milk concentrations of most minerals showed seasonal variations with K and Zn being consistently higher in June than in October. In both experiments most milk samples had lower mineral concentrations than the reference values given by Underwood (1981) for cow's milk; however, these reference values may be overestimated, since other studies on mineral supplementation in central Florida have reported similar concentrations to the ones found in the present study.

With the exception of serum P in the cows, the overall mineral status of these cattle based on serum, liver, milk and hair analyses may be considered adequate, mainly due to the supplemental free-choice mineral salt provided to all the animals.

Cows lost weight from March to October, but BCS in October were slightly higher than in March. Selenium supplemented cows at Williston were the only cows gaining weight from June-October and their calves had higher ADG than control calves.

Experiment 3 was conducted with 2 to 3 years old pregnant heifers. Heifers were crossbred Angus X Brahman and within each breed group were randomly assigned to the experimental groups, which included a treatment combination consisting of 3 levels of Se (0, 1.0 and 1.5 mg Se/kg live weight); and two levels of vitamin E (4.5 and 9.0 mg α-tocopherol/kg live weight).

Experiment 4 was conducted with 2 to 3 years old pregnant ewes. Ewes were Florida native and were randomly assigned to seven experimental groups using the same levels and treatment combinations as described for heifers.

Both Se and vitamin E were applied by intramuscular injection and the sources were sodium selenite and dl-α-tocopherol, respectively. Treatments were applied one to two months before parturition in the heifers and one month before parturition in the ewes. Blood samples from the cows and ewes were collected before the treatments were applied, at parturition, and at one and two months. After parturition, blood samples from calves and lambs were taken at birth, and at one and two months of age, simultaneously with colostrum and milk samples from their mothers. Serum samples were analyzed for Se and vitamin E and colostrum and milk samples for Se.

There was no effect of Se and vitamin E treatments on serum Se concentrations of ewes and lambs, and vitamin E concentrations of cows and ewes. Selenium supplementation increased Se concentrations in serum of cows and colostrum of cows and ewes, with the response being also higher in milk Se concentrations at one month in ewes treated with 1.5 mg Se/kg live weight.

Brahman cows had lower colostrum Se concentrations than crossbred cows, but higher milk Se concentrations at one and two months than crossbred cows. Similarly, serum Se concentrations of Brahman cows were lower at pre-treatment and parturition than the crossbred cows, but higher at two months. Likewise, serum vitamin E concentrations of Brahman cows were higher than the crossbred cows at one and two months. These higher Se and vitamin E concentrations of Brahman cows after parturition may reflect more availability of these nutrients in the pasture in March-April than in January-February, when most of the samples from the crossbred cows were collected.

Calves had lower serum Se concentrations at two months than at birth or one month of age; however, the lowest serum vitamin E concentrations were recorded at birth and the highest at two months; thus indicating inefficient placental transfer of vitamin E, but an important transfer from colostrum as well as a direct contribution from pasture during the early grazing in the spring.

Serum Se concentrations of ewes were lower at pre-partum than after parturition; however the highest serum vitamin E concentrations were recorded at pre-treatment, and the lowest at one and two months after parturition. Lambs from ewes treated with the high dose of vitamin E (9 mg α-tocopherol/kg) had higher serum vitamin E concentrations than with the low vitamin E dose.

The low responses to the Se and vitamin E applied in these two experiments may be due to the fact that the nutritional status of cows and ewes at treatment time was relatively adequate.

APPENDIX A

SUPPLEMENTARY TABLES

TABLE A.1. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), MONTH (M) AND INTERACTION (L*M) ON SOIL pH, ORGANIC MATTER (OM) AND MACROMINERALS

	Response Variable						
Effect	pH	OM	Ca	P	Mg	K	Na
			1988				
L[a]	.41	.11	.64	.12	.49	.58	.65
M[b]	.23	.02	.49	.67	.87	.10	.46
L*M	.35	.01	.68	.62	.58	.47	.77
			1989				
L	.12	.09	.22	.14	.10	.03	.10
M	.04	.54	.09	.43	.78	.01	.14
L*M	.19	.39	.04	.10	.49	.05	.39

[a] L = Bronson and Williston.

[b] M = June and October in 1988; and March, May, June, August and October in 1989.

TABLE A.2. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), MONTH (M) AND INTERACTION (L*M) ON SOIL TRACE MINERALS

	Response Variable					
Effect	Cu	Zn	Fe	Mn	Al	Se
			1988			
L[a]	.13	.10	.03	.03	.04	.02
M[b]	.42	.65	.73	.09	.46	.10
L*M	.82	.39	.49	.06	.42	.91
			1989			
L	.31	.07	.47	.01	.09	.63
M	.90	.04	.42	.01	.01	.08
L*M	.97	.73	.64	.01	.04	.04

[a] L = Bronson and Williston.

[b] M = June and October in 1988; and March, May, June, August and October in 1989.

TABLE A.3. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), MONTH (M) AND INTERACTION (L*M) ON FORAGE MACROMINERALS AND PROTEIN

Effect	Response Variable					
	Ca	P	K	Mg	Na	Protein
				1988		
L[a]	.92	.59	.35	.05	.27	.28
M[b]	.12	.03	.01	.74	.16	.12
L*M	.94	.27	.10	.58	.73	.78
				1989		
L	.02	.69	.14	.96	.99	.04
M	.01	.01	.01	.05	.01	.01
L*M	.12	.42	.61	.14	.44	.29

[a] L = Bronson and Williston.

[b] M = June and October in 1988; and March, May, June, August and October in 1989.

TABLE A.4. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), MONTH (M) AND INTERACTION (L*M) ON FORAGE TRACE MINERALS

	Response Variable						
Effect	CU	Zn	Fe	Mn	Co	Mo	Se
			1988				
L[a]	.42	.17	.27	.01	.06	.08	.05
M[b]	.03	.01	.11	.01	.53	.18	.30
L*M	.30	.32	.64	.01	.29	.66	.32
			1989				
L	.99	.14	.19	.04	.12	.01	.23
M	.02	.03	.16	.01	.01	.01	.01
L*M	.12	.96	.93	.01	.13	.02	.22

[a] L = Bronson and Williston.
[b] M = June and October in 1988; and March, May, June, August and October in 1989.

TABLE A.5. SOIL pH, ORGANIC MATTER AND MINERAL CORRELATION COEFFICIENTS[a]

	pH	OM	Ca	P	Mg	K	Na	Cu	Zn	Fe	Mn	Al	Se
pH	1.00												
OM	-.46	1.00											
Ca	.45	.07	1.00										
P	.30	.30	.29	1.00									
Mg	.08	.48	.60**	.40	1.00								
K	-.13	.31	.23	.06	.44	1.00							
Na	.13	.00	.15	.09	.04	.02	1.00						
Cu	.36	-.12	.48	.07	.21	.25	.14	1.00					
Zn	-.33	.22	.11	-.02	.43	.36	-.08	.16	1.00				
Fe	-.39	.42	-.22	.26	.04	.03	.02	-.22	.06	1.00			
Mn	-.32	.25	.32	-.22	.42	.53**	-.02	.35	.55**	.09	1.00		
Al	.21	.32	.18	.09	.25	-.09	.06	-.08	-.20	.29	-.39	1.00	
Se	.11	.03	.02	.31	.13	.08	.05	.22	.00	.15	-.08	.24	1.0

[a] Correlations of 119 samples.
**P<.01.

TABLE A.6. FORAGE MINERAL AND PROTEIN CORRELATION COEFFICIENTS[a]

	Ca	P	K	Mg	Na	Cu	Zn	Fe	Mn	Co	Mo	Se	Protein
Ca	1.00												
P	.22	1.00											
K	.22	.42	1.00										
Mg	.45	.16	.32	1.00									
Na	.43	.30	.41	.21	1.00								
Cu	.11	.50**	.58**	.27	.36	1.00							
Zn	.42	.39	.57**	.08	.43	.41	1.00						
Fe	.49	.14	.11	.09	.41	.05	.48	1.00					
Mn	.12	.04	.35	-.11	.19	.03	.34	.00	1.00				
Co	.21	-.15	.29	.06	.22	.09	.53**	.30	.53**	1.00			
Mo	-.24	.15	.13	-.02	-.09	.26	.03	-.13	-.28	-.05	1.00		
Se	.10	-.17	-.48	-.09	-.18	-.40	-.19	.08	-.18	-.13	-.14	1.00	
CP	.46	.43	.42	.33	.51**	.50**	.44	.36	.05	.11	.03	-.15	1.00

[a] Correlations of 119 samples.
[b] CP = crude protein.
[**] P<.01.

TABLE A.7. SOIL/FORAGE MINERAL AND PROTEIN CORRELATION COEFFICIENTS[a]

	Ca	P	K	Mg	Na	Cu	Zn	Fe	Mn	Co	Mo	Se	Protein
pH	.18	-.33	-.17	.16	.01	-.18	.05	.29	-.20	.21	.05	.13	.14
OM	-.13	.29	.29	.06	-.01	.22	-.11	-.31	.13	-.22	.00	-.18	.01
Ca	.03	-.18	-.01	.08	-.12	-.15	.05	.01	.19	.40	-.06	.06	-.06
P	.02	.01	-.09	.33	-.11	-.05	-.12	-.01	-.32	-.15	.19	.12	.17
Mg	-.12	.12	.08	.07	-.17	-.07	-.08	-.22	.07	.03	-.02	-.05	-.05
K	-.08	.28	.22	-.06	.05	-.01	.06	-.06	.32	.06	-.19	-.15	-.02
Cu	.11	-.20	.05	.03	.08	-.06	.16	.16	.28	.36	-.22	-.10	.01
Zn	-.23	.24	-.04	-.22	-.22	.08	-.01	-.13	.11	-.09	-.08	-.05	-.19
Fe	.01	.20	.15	.18	.16	.21	.05	-.04	.14	-.04	-.13	-.02	.19
Mn	-.05	.10	.23	-.12	-.09	.10	.20	-.13	.56**	.37	-.25	-.21	-.13
Al	-.02	-.03	-.15	.32	-.03	-.05	-.21	-.03	-.37	-.22	.16	.20	.19
Na	.01	-.14	-.01	-.09	.10	-.17	-.01	.14	-.03	.02	-.15	-.14	.05
Se	.09	.02	-.18	.00	.08	-.16	.44	.10	-.19	-.15	-.17	.16	-.03

[a] Correlations of 119 samples, with soil variables in the column and forage variables in the row.

**P<.01.

TABLE A.8. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), MONTH (M) AND INTERACTION EFFECTS ON SERUM SELENIUM OF COWS AND CALVES (EXPERIMENT 1)

	COWS					
Effect	June	Oct.	Gral[a]	June	Oct.	Gral[a]
L[b]	.12	.10	.10	.01	.10	.44
Se	.82	.01	.01	.42	.01	.04
L*Se	.99	.82	.83	.22	.03	.03
M			.01			.01
L*M			.64			.01
Se*M			.01			.01
L*Se*M			.83			.52

[a] Gral = General Linear Models Procedure for Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

TABLE A.9. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON SERUM SELENIUM OF COWS AND CALVES (EXPERIMENT 2)

	COWS				CALVES		
Effect	March	June	Oct.	Gral[a]	June	Oct.	Gral[a]
L[b]	.04	.94	.01	.01	.56	.01	.03
Se	.01	.01	.01	.01	.39	.49	.27
L*Se	.19	.24	.34	.52	.28	.75	.32
VE	.94	.08	.75	.29	.99	.66	.76
L*VE	.91	.82	.80	.94	.57	.62	.97
Se*VE	.94	.87	.52	.68	.60	.07	.09
L*Se*VE	.10	.99	.35	.15	.33	.05	.44
M				.01			.01
L*M				.04			.16
Se*M				.63			.92
L*Se*M				.12			.61
VE*M				.43			.75
L*VE*M				.94			.46
Se*VE*M				.94			.34
L*Se*VE*M				.34			.04

[a] Gral = General Linear Models Procedure for Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

TABLE A.10. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON SERUM VITAMIN E OF COWS AND CALVES (EXPERIMENT 2)

	COWS				CALVES		
Effect	March	June	Oct.	Gral[a]	June	Oct.	Gral[a]
L[b]	.01	.01	.48	.01	.06	.94	.25
Se	.03	.02	.83	.08	.06	.02	.02
L*Se	.04	.01	.02	.01	.95	.01	.16
VE	.88	.94	.88	.98	.67	.53	.97
L*VE	.95	.41	.65	.85	.98	.97	.99
Se*VE	.12	.71	.15	.17	.84	.05	.40
L*Se*VE	.84	.31	.82	.74	.37	.50	.37
M				.01			.01
L*M				.01			.03
Se*M				.03			.95
L*Se*M				.21			.02
VE*M				.96			.29
L*VE*M				.43			.96
Se*VE*M				.60			.04
L*Se*VE*M				.37			.67

[a] Gral = General Linear Models Procedure for Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

TABLE A.11. PROBABILITY LEVELS (F TEST) FOR LOCATION (LO), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON LIVER SELENIUM

Effect	Experiment 1	Experiment 2
L[b]	.89	.93
Se	.64	.01
L*Se	.45	.08
VE	--	.55
L*VE	--	.73
Se*VE	--	.94
L*Se*VE	--	.54
M	.01	.01
L*M	--	.27
Se*M	--	.34
L*Se*M	--	.59
VE*M	--	.69
L*VE*M	--	.72
Se*VE*M	--	.75

[a] Gral = General Linear Models Procedure for Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

TABLE A.12. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON MILK SELENIUM

	Experiment 1			Experiment 2		
	June	Oct.	Gral[a]	June	Oct.	Gral[a]
L[b]	.71	.01	.01	.04	.05	.97
Se	.03	.01	.01	.49	.01	.01
L*Se	.98	.02	.05	.06	.78	.12
VE			--	.33	.66	.31
L*VE			--	.20	.41	.12
Se*VE			--	.13	.30	.07
L*Se*VE			--	.24	.44	.79
M			.01			.01
L*M			.20			.01
Se*M			.01			.01
L*Se*M			.05			.29
VE*M			--			.73
L*VE*M			--			.78
Se*VE*M			--			.78
L*Se*VE*M			--			.18

[a] Gral = General Linear Models Procedure for Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

TABLE A.13. PROBABILITY LEVELS (F TEST) FOR LOCATION (LO), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON HAIR SELENIUM

	Experiment 1			Experiment 2			
Effect	June	Oct.	Gral[a]	March	June	Oct.	Gral[a]
L[b]	.29	.12	.67	.61	.72	.17	.51
Se	.39	.05	.42	.01	.42	.03	.01
L*Se	.12	.13	.06	.93	.02	.11	.32
VE			--	.44	.48	.97	.46
L*VE			--	.97	.22	.72	.31
Se*VE			--	.89	.84	.92	.95
L*Se*VE			--	.85	.65	.79	.38
M			.07				.01
L*M			.04				.55
Se*M			.02				.65
L*Se*M			.93				.01
VE*M			--				.73
L*VE*M			--				.31
Se*VE*M			--				.95
L*Se*VE*M			--				.75

[a] Gral = General Linear Models Procedure for Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

TABLE A.14. TISSUE AND FLUIDS SELENIUM CORRELATION COEFFICIENTS OF COWS AND CALVES

	Liver	Milk	Serum[a]	Hair	Serum[b]	VitE[a]	VitE[b]
Liver	1.00						
Milk	.16	1.00					
Serum[a]	.38	.12	1.00				
Hair	.26	.03	.00	1.00			
Serum[b]	.28	-.12	-.12	-.11	1.00		
VitE[a]	-.23	.05	-.34	.06	-.08	1.00	
VitE[b]	-.29	-.21	-.28	-.04	.03	.15	1.00

**P<.01.

[a] Serum or vitamin E from cows.

[b] Serum or vitamin E from calves.

Correlations of the following number of samples: liver 72, milk 73, serum cows 157, vitamin E of cows 155, hair 156, serum calves 50, vitamin E of calves 53.

TABLE A.15. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), MONTH (M) AND INTERACTION EFFECTS ON SERUM MINERALS OF COWS (EXPERIMENT 1)[a]

	RESPONSE VARIABLES					
EFFECT	Ca	P	Mg	Cu	Zn	Fe
L[b]	.18	.68	.14	.63	.66	.05
Se	.46	.45	.13	.02	.02	.47
L*Se	.08	.05	.18	.80	.19	.01
M[c]	.01	.11	.01	.67	.01	.01
L*M	.72	.23	.94	.93	.27	.82
Se*M	.01	.01	.87	.40	.07	.41
L*Se*M	.29	.24	.01	.87	.04	.38

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

[c] M = June and October.

TABLE A.16. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), MONTH (M) AND INTERACTION EFFECTS ON SERUM MINERALS OF CALVES (EXPERIMENT 1)[a]

	RESPONSE VARIABLES					
EFFECT	Ca	P	Mg	Cu	Zn	Fe
L[b]	.01	.01	.04	.03	.01	.02
Se	.31	.12	.89	.50	.07	.08
L*Se	.05	.47	.37	.30	.09	.09
M	.01	.01	.01	.03	.46	.01
L*M	.36	.37	.05	.24	.11	.01
Se*M	.02	.20	.53	.25	.34	.25
L*Se*M	.01	.12	.02	.37	.01	.22

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance.
[b] L = Bronson and Williston.
[c] M = June and October.

TABLE A.17. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se) AND INTERACTION L*Se BY SAMPLING MONTH ON SERUM MINERALS OF COWS AND CALVES (EXPERIMENT 1)[a]

		Response variables					
Month	Effect	Ca	P	Mg	Cu	Zn	Fe
				COWS			
June	L[b]	.51	.59	.29	.72	.67	.23
	Se	.21	.19	.26	.05	.01	.32
	L*Se	.10	.63	.83	.81	.02	.01
October	L	.08	.20	.09	.66	.27	.07
	Se	.01	.01	.10	.06	.59	.97
	L*Se	.34	.02	.01	.89	.57	.01
				CALVES			
June	L	.03	.01	.02	.04	.01	.01
	Se	.07	.07	.81	.31	.10	.52
	L*Se	.01	.14	.08	.26	.01	.04
October	L	.01	.01	.61	.11	.07	.73
	Se	.14	.86	.39	.89	.47	.04
	L*Se	.21	.47	.13	.64	.35	.56

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance by sampling month.

[b] L = Location (Bronson and Williston).

TABLE A.18. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON SERUM MINERALS OF COWS (EXPERIMENT 2)[a]

Effect	Response variable					
	Ca	P	Mg	Cu	Zn	Fe
L[b]	.42	.43	.01	.02	.93	.01
Se	.01	.01	.66	.04	.50	.24
L*Se	.20	.01	.01	.30	.06	.32
VE	.14	.63	.91	.77	.29	.11
L*VE	.16	.87	.01	.59	.68	.82
Se*VE	.07	.89	.87	.48	.56	.23
L*Se*VE	.24	.06	.76	.29	.04	.80
M[c]	.01	.01	.01	.01	.01	.01
L*M	.01	.01	.01	.01	.01	.01
Se*M	.01	.56	.01	.01	.01	.01
L*Se*M	.03	.30	.38	.02	.08	.04
VE*M	.17	.89	.84	.30	.35	.57
L*VE*M	.17	.97	.94	.98	.32	.76
Se*VE*M	.22	.28	.10	.44	.43	.17
L*SE*VE*M	.31	.21	.86	.87	.03	.92

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

[c] M = March, June and October.

TABLE A.19. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE) AND INTERACTION EFFECTS BY SAMPLING MONTH (M) ON SERUM MINERALS OF COWS (EXPERIMENT 2)[a]

		Response variables					
Month	Effect	Ca	P	Mg	Cu	Zn	Fe
March	L[b]	.19	.06	.01	.83	.65	.66
	Se	.01	.01	.26	.39	.01	.01
	L*Se	.25	.01	.03	.35	.04	.78
	VE	.95	.08	.89	.82	.17	.20
	L*VE	.62	.91	.02	.77	.56	.72
	Se*VE	.98	.69	.72	.94	.27	.33
	L*Se*VE	.10	.16	.74	.40	.04	.92
June	L	.02	.05	.67	.23	.02	.10
	Se	.05	.04	.10	.01	.04	.20
	L*Se	.13	.01	.01	.11	.06	.62
	VE	.43	.81	.74	.79	.96	.88
	L*VE	.79	.78	.06	.63	.52	.66
	Se*VE	.08	.32	.37	.72	.98	.46
	L*Se*VE	.11	.85	.67	.34	.03	.88
October	L	.01	.10	.01	.01	.01	.01
	Se	.01	.01	.05	.97	.01	.01
	L*Se	.04	.01	.01	.05	.98	.01
	VE	.07	.82	.83	.14	.28	.11
	L*VE	.06	.97	.03	.63	.21	.57
	Se*VE	.11	.37	.25	.11	.99	.03
	L*Se*VE	.84	.04	.98	.55	.78	.59

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance. Analysis by sampling month.

[b] L = Location (Bronson and Williston).

TABLE A.20. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (Ve), MONTH (M) AND INTERACTION EFFECTS ON SERUM MINERALS OF CALVES (EXPERIMENT 2)[a]

Response	Effect					
Variable	Ca	P	Mg	Cu	Zn	Fe
L[b]	.01	.01	.05	.01	.06	.01
Se	.25	.15	.37	.08	.01	.02
L*Se	.68	.66	.56	.01	.31	.68
VE	.34	.39	.34	.51	.97	.18
L*VE	.67	.33	.06	.22	.68	.32
Se*VE	.24	.85	.48	.23	.49	.61
L*Se*VE	.67	.56	.76	.67	.31	.03
M[c]	.01	.01	.01	.01	.01	.01
L*M	.01	.07	.21	.01	.05	.01
Se*M	.09	.01	.22	.01	.29	.01
L*Se*M	.21	.69	.35	.35	.61	.01
VE*M	.52	.38	.43	.91	.59	.59
L*VE*M	.28	.59	.69	.69	.97	.83
Se*VE*M	.19	.02	.51	.46	.13	.47
L*SE*VE*M	.32	.83	.86	.26	.25	.04

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

[c] M = June and October.

TABLE A.21. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE) AND INTERACTION EFFECTS BY MONTH ON SERUM MINERALS OF CALVES (EXPERIMENT 2)[a]

		Response variables					
Month	Effect	Ca	P	Mg	Cu	Zn	Fe
June	L[b]	.01	.01	.03	.01	.04	.01
	Se	.01	.74	.19	.01	.01	.44
	L*Se	.01	.51	.96	.06	.39	.03
	VE	.63	.91	.26	.57	.76	.27
	L*VE	.27	.22	.10	.25	.79	.47
	Se*VE	.80	.13	.38	.65	.23	.48
	L*Se*VE	.35	.73	.87	.72	.23	.02
October	L	.05	.27	.32	.01	.92	.01
	Se	.76	.01	.96	.22	.01	.01
	L*Se	.65	.94	.27	.01	.50	.01
	VE	.40	.27	.71	.64	.58	.37
	L*VE	.42	.70	.14	.45	.64	.39
	Se*VE	.18	.13	.82	.14	.40	.89
	L*Se*VE	.46	.59	.70	.28	.77	.93

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance. Analysis by sampling month.

[b] L = Location (Bronson and Williston).

TABLE A.22. SERUM MINERAL CORRELATION COEFFICIENTS OF COWS (EXPERIMENT 1)[a]

	Ca	P	Mg	Cu	Zn	Fe
Ca	1.00					
P	.04	1.00				
Mg	.40	-.10	1.00			
Cu	.22	.19	.29	1.00		
Zn	.63**	-.01	.34	.32	1.00	
Fe	-.28	.16	.04	.19	-.07	1.00

[a] Correlations of 92 samples.
**P<.01.

TABLE A.23. SERUM MINERAL CORRELATION COEFFICIENTS OF CALVES (EXPERIMENT 1)[a]

	Ca	P	Mg	Cu	Zn	Fe
Ca	1.00					
P	.15	1.00				
Mg	.71**	.23	1.00			
Cu	.36	.50	-.36	1.00		
Zn	.53**	.51	.41	.39	1.00	
Fe	.33	.48	.32	.31	.54**	1.00

[a] Correlations of 83 samples.
**P<.01.

TABLE A.24. SERUM MINERAL CORRELATION COEFFICIENTS OF COWS (EXPERIMENT 2) [a]

	Ca	P	Mg	Cu	Zn	Fe
Ca	1.00					
P	.23	1.00				
Mg	.02	.06	1.00			
Cu	.51**	-.02	.08	1.00		
Zn	.38	.04	-.12	-.32	1.00	
Fe	.54**	-.11	.06	-.13	.34	1.00

[a] Correlations of 240 samples.
**P<.01.

TABLE A.25. SERUM MINERAL CORRELATION COEFFICIENTS OF CALVES (EXPERIMENT 2)[a]

	Ca	P	Mg	Cu	Zn	Fe
Ca	1.00					
P	.46	1.00				
Mg	.46	.42	1.00			
Cu	.29	.02	.22	1.00		
Zn	-.40	.03	-.26	-.58**	1.00	
Fe	-.40	-.12	-.12	.11	.16	1.00

[a] Correlations of 126 samples.
**P<.01.

TABLE A.26. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON LYMPHOCYTE BLASTOGENIC RESPONSE OF COWS (EXPERIMENT 2)[a]

	Response Variables[b]		
Effect	PHA	Con A	IL-2
L[c]	.88	.26	.81
Se	.21	.61	.06
L*Se	.98	.35	.40
VE	.21	.03	.03
L*VE	.04	.05	.40
Se*VE	.36	.61	.12
L*Se*VE	.73	.59	.44
M[d]	.01	.01	.01
L*M	.10	.30	.01
Se*M	.13	.32	.01
L*Se*M	.38	.96	.96
VE*M	.46	.06	.15
L*VE*M	.41	.16	.24
Se*VE*M	.77	.62	.54
L*Se*VE*M	.57	.68	.08

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance.

[b] PHA = phytohemagglutinin, Con A = concanavalin A, IL-2 = Human recombinant interleukin.

[c] L = Location (Bronson and Williston).

[d] M = March, June and October.

TABLE A.27. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS BY MONTH ON LYMPHOCYTE BLASTOGENIC RESPONSE OF COWS (EXPERIMENT 2)[a]

		Response variables[b]		
Month	Effect	PHA	Con A	IL-2
March	L[c]	.49	.48	.27
	Se	.10	.08	.01
	L*Se	.37	.72	.81
	VE	.60	.07	.08
	L*VE	.13	.68	.76
	Se*VE	.45	.27	.28
	L*Se*VE	.93	.87	.13
June	L	.01	.59	.01
	Se	.29	.73	.96
	L*Se	.23	.59	.52
	VE	.67	.31	.58
	L*VE	.92	.39	.84
	Se*VE	.90	.48	.96
	L*Se*VE	.32	.89	.18
October	L	*.28*	*.19*	*.01*
	Se	.44	.50	.38
	L*Se	.59	.61	.54
	VE	.12	.04	.06
	L*VE	.18	.06	.10
	L*Se	.60	.73	.20
	L*Se*VE	.33	.44	.20

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance. Analysis by sampling month.

[b] PHA = phytohemagglutinin, Con A = concanavalin A, IL-2 = human recombinant interleukin.

[c] L = Location (Bronson and Williston).

TABLE A.28. PROBABILITY LEVELS (F TEST) FOR LOCATION, SELENIUM (Se), VITAMIN E (VE) AND INTERACTION EFFECTS ON WEIGHT CHANGES AND CONDITION SCORES OF COWS (EXPERIMENT 2)

	Response variable[a]					
Effect	Ini. Wt.	Diff.1	C.Sc.1	Diff.2	Diff.3	C.Sc.3
L[b]	.01	.01	.31	.01	.01	.01
Se	.07	.01	.31	.01	.01	.05
L*Se	.10	.01	.09	.01	.01	.03
VE	.12	.73	.62	.63	.71	.39
L*VE	.25	.08	.15	.81	.27	.96
Se*VE	.16	.59	.68	.72	.56	.24
L*Se*VE	.17	.15	.27	.41	.03	.73

[a] Ini. Wt. = March; Diff.1 = March-June weight; Diff.2 = June-October weight; Diff.3 = March-October weight; C.Sc.1 = condition score in March; C.Sc.3 = condition score in October.
[b] L = Bronson and Williston.

TABLE A.29. PROBABILITY LEVELS (F TEST) FOR LOCATION, SELENIUM (Se), VITAMIN E (VE) AND INTERACTION EFFECTS ON WEIGHT GAIN OF CALVES (EXPERIMENT 2)

	Response variable	
Effect	Initial weight	June-October
L[b]	.46	.53
Se	.74	.72
L*Se	.83	.05
VE	.14	.40
L*VE	.41	.91
Se*VE	.85	.55
L*Se*VE	.22	.31

[a] L = Bronson and Williston.

TABLE A.30. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), MONTH (M) AND INTERACTION EFFECTS ON LIVER MINERALS (EXPERIMENT 1)[a]

	Response variables					
Effect	Cu	Zn	Fe	Mn	Co	Mo
L[b]	.02	.38	.88	.39	.57	.03
Se	.01	.07	.14	.11	.02	.43
L*Se	.62	.11	.20	.83	.77	.60
M[c]	.01	.83	.81	.20	.56	.85
L*M	.02	.52	.79	.38	.52	.82
Se*M	.06	.84	.66	.22	.71	.64

[a] General Linear Models Procedure of Analysis of Variance.

[b] L = Bronson and Williston.

[c] M = June and October.

TABLE A.31. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON LIVER MINERALS (EXPERIMENT 2)[a]

	Response variable					
Effect	Cu	Zn	Fe	Mn	Co	Mo
L[b]	.01	.49	.39	.15	.01	.47
Se	.36	.99	.06	.25	.99	.22
L*Se	.01	.72	.56	.83	.03	.34
VE	.84	.35	.98	.17	.84	.45
L*VE	.89	.60	.75	.57	.03	.54
Se*VE	.68	.49	.66	.24	.56	.24
L*Se*VE	.01	.60	.44	.54	.16	.15
M[c]	.02	.36	.03	.78	.01	.38
L*M	.25	.49	.24	.27	.44	.81
Se*M	.03	.88	.04	.31	.40	.66
L*Se*M	.35	.36	.12	.98	.27	.20
VE*M	.01	.79	.62	.29	.20	.14
L*VE*M	.30	.85	.97	.17	.60	.59
Se*VE*M	.75	.77	.90	.70	.47	.86

[a] General Linear Models Procedure of Analysis of Variance.

[b] L = Bronson and Williston.

[c] M = June and October.

TABLE A.32. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), MONTH (M) AND INTERACTION EFFECTS ON MILK MINERALS (EXPERIMENT 1)[a]

	Response variables						
Effect	Ca	P	K	Mg	Na	Cu	Zn
L[b]	.32	.85	.11	.97	.71	.63	.30
Se	.95	.65	.91	.62	.86	.41	.15
L*Se	.48	.06	.56	.61	.69	.27	.90
M[c]	.05	.01	.03	.01	.01	.38	.01
L*M	.48	.43	.02	.24	.86	.50	.69
Se*M	.91	.13	.09	.47	.70	.03	.70
L*Se*M	.32	.63	.80	.63	.98	.96	.39

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance.

[b] L = Bronson and Williston.

[c] M = June and October.

TABLE A.33. PROBABILITY LEVES (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE), MONTH (M) AND INTERACTION EFFECTS ON MILK MINERALS (EXPERIMENT 2)[a]

	Response variable						
Effect	Ca	P	K	Mg	Na	Cu	Zn
L[b]	.03	.74	.12	.15	.80	.08	.02
Se	.01	.83	.39	.66	.18	.19	.55
L*Se	.03	.91	.42	.87	.97	.04	.57
VE	.56	.65	.97	.14	.37	.71	.70
L*VE	.41	.34	.48	.92	.97	.83	.30
Se*VE	.82	.36	.49	.36	.52	.59	.35
L*Se*VE	.98	.50	.84	.16	.38	.22	.69
M[c]	.01	.01	.01	.51	.01	.01	.01
L*M	.98	.14	.71	.57	.06	.35	.62
Se*M	.02	.01	.17	.44	.36	.79	.14
L*Se*M	.01	.01	.36	.39	.99	.14	.66
VE*M	.56	.50	.15	.61	.33	.94	.56
L*VE*M	.85	.22	.12	.77	.38	.73	.43
Se*VE*M	.85	.22	.12	.77	.38	.73	.43
L*SE*VE*M	.20	.92	.74	.48	.11	.23	.35

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance.
[b] L = Bronson and Williston.
[c] M = June and October.

TABLE A.34. PROBABILITY LEVELS (F TEST) FOR LOCATION (L), SELENIUM (Se), VITAMIN E (VE) AND INTERACTION EFFECTS BY SAMPLING MONTH ON MILK MINERALS[a].

		Response variables						
Month	Effect	Ca	P	K	Mg	Na	Cu	Zn
		Experiment 1						
June	L[b]	.98	.27	.36	.48	.88	.08	.24
	Se	.77	.83	.01	.59	.88	.50	.75
	L*Se	.96	.17	.78	.89	.74	.47	.44
October	L	.88	.69	.19	.99	.71	.26	.57
	Se	.11	.56	.74	.41	.72	.91	.35
	L*Se	.13	.05	.49	.41	.80	.29	.54
		Experiment 2						
June	L	.06	.24	.15	.09	.25	.17	.21
	Se	.37	.07	.12	.97	.57	.60	.23
	L*Se	.83	.11	.97	.72	.98	.07	.89
	VE	.88	.97	.34	.26	.92	.88	.96
	L*VE	.80	.61	.19	.70	.38	.63	.29
	Se*VE	.94	.14	.12	.30	.24	.93	.30
	L*Se*VE	.43	.54	.71	.35	.73	.21	.44
October	L	.08	.54	.33	.39	.20	.03	.01
	Se	.01	.16	.86	.48	.14	.01	.52
	L*Se	.01	.17	.24	.60	.97	.13	.35
	VE	.42	.45	.38	.17	.24	.25	.40
	L*VE	.29	.30	.86	.88	.51	.17	.64
	Se*VE	.78	.99	.65	.57	.98	.03	.78
	L*Se*VE	.47	.64	.96	.16	.13	.97	.71

[a] General Linear Models Procedure of Repeated Measures Analysis of Variance by sampling month.

[b] L = Location (Bronson and Williston).

TABLE A.35. LIVER MINERAL CORRELATION COEFFICIENTS (EXPERIMENT 1)

	Cu	Zn	Fe	Mn	Co	Mo
Cu	1.00					
Zn	.32	1.00				
Fe	-.21	.34	1.00			
Mn	.00	-.05	.36	1.00		
Co	.47	.28	-.44	-.29	1.00	
Mo	.00	.36	.36	.43	-.10	1.00

**P<.01.
Correlations of 23 samples.

TABLE A.36. LIVER MINERAL CORRELATION COEFFICIENTS (EXPERIMENT 2)

	Cu	Zn	Fe	Mn	Co	Mo
Cu	1.00					
Zn	-.02	1.00				
Fe	-.27	.13	1.00			
Mn	-.32	.26	.80**	1.00		
Co	-.48	.34	.40	.68**	1.00	
Mo	-.49	.04	.39	.42	.59**	1.00

**P<.01.
Correlations of 60 samples.

TABLE A.37. MILK MINERAL CORRELATION COEFFICIENTS (EXPEIMENT 1)

	Ca	P	K	Mg	Na	Cu	Zn
Ca	1.00						
P	.03	1.00					
K	.18	.27	1.00				
Mg	.78**	-.09	.16	1.00			
Na	.08	-.15	-.12	.30	1.00		
Cu	.15	.12	.04	.08	-.07	1.00	
Zn	-.14	.29	.21	-.26	-.37	.13	1.00

**P<.01.
Correlations of 82 samples.

TABLE A.38. MILK MINERAL CORRELATION COEFFICIENTS (EXPERIMENT 2)

	Ca	P	K	Mg	Na	Cu	Zn
Ca	1.00						
P	.07	1.00					
K	.26	.10	1.00				
Mg	.41	.39	.22	1.00			
Na	-.08	.06	-.09	.18	1.00		
Cu	.41	-.12	.19	.12	-.03	1.00	
Zn	.48	.26	.41	.28	-.07	.54**	1.00

**P<.01.
Correlations of 153 samples.

TABLE A.39. PROBABILITY LEVELS FOR SELENIUM (Se), VITAMIN E (VE), BREED, PERIOD AND INTERACTION EFFECTS ON SERUM Se AND VITAMIN E, AND MILK Se OF COWS AND CALVES (EXPERIMENT 3)

	COWS			CALVES	
Effect	Milk Se	Serum Se	VE	Serum Se	VE
Se	.23	.02	.19	.75	.03
VE	.28	.52	.10	.98	.28
Se*VE	.31	.71	.15	.38	.25
Breed[a]	.12	.94	.01	.45	.80
Period[b]	.01	.01	.01	.08	.01
Se*Period	.03	.81	.59	.32	.11
VE*Period	.30	.40	.67	.79	.60
Breed*Period	.02	.01	.01	.17	.06

[a] Groups 3, 4 and 6 for cows and 2, 3, 4 and 5 for calves.

[b] Pre-treatment, Parturition, 1 and 2 months for cows; and for calves all, except pre-treatment.

TABLE A.40. PROBABILITY LEVELS FOR SELENIUM (Se), VITAMIN E (VE), SEX, PERIOD AND INTERACTION EFFECTS ON SERUM Se AND VITAMIN E, AND MILK SELENIUM OF EWES AND LAMBS (EXPERIMENT 4)

	Response variable		
	Milk Se	Serum Se	Vitamin E
Effect		E W E S	
Se	.01	.61	.40
VE	.13	.55	.87
Se*VE	.47	.67	.24
Period[a]	.01	.01	.01
Se*Period	.01	.48	.14
VE*Period	.02	.56	.80
Se*VE*Period	.31	.42	.63
		L A M B S	
Se	--	.94	.27
VE	--	.62	.03
Se*VE	--	.98	.99
Sex	--	.83	.92
Period[a]	--	.65	.01
Se*Period	--	.36	.50
VE* Period	--	.32	.01

[a] Pre-treatment, Parturition, 1 and 2 months for ewes; and for lambs all, except pre-treatment.

APPENDIX B
RAW DATA

SOIL DATA CODES

OB = Observation number (1-119).

PA = Pasture (1-4).

LO = Location: 1. Bronson.
2. Williston.

YR = Year (88 and 89).

MT = Month: 3. March.
5. May.
6. June.
8. August.
10. October.

OS = Sample observation number.

Macrominerals (Dry matter basis), pH and OM.

Ca = Calcium, ppm.
P = Phosphorus, ppm.
Mg = Magnesium, ppm.
K = Potassium, ppm.
Na = Sodium, ppm.
Al = Aluminum, ppm
pH = Soil pH.
OM = Organic matter, %.

Trace elements (Dry matter basis)

Cu = Copper, ppm.
Zn = Zinc, ppm.
Fe = Iron, ppm.
Mn = Manganese, ppm.
Se = Selenium, ppm.

SOILS DATA

OB	PA	LO	YR	MT	OS	pH	OM	Ca	P	Mg	K	Na	Cu	Zn	Fe	Mn	Al	Se
1	1	1	88	6	1	5.8	1.3	176	11.2	16.4	8.8	8.0	0.08	0.48	12.4	1.7	110	0.140
2	1	1	88	6	2	6.4	0.9	168	26.8	41.2	22.4	7.2	0.12	0.68	8.0	1.8	88	0.098
3	1	1	88	6	3	5.9	0.9	88	14.4	16.4	18.8	7.6	0.08	0.40	11.2	1.2	96	0.147
4	1	1	88	6	4	5.7	1.1	162	13.2	16.0	8.8	8.0	0.04	0.28	12.8	2.0	119	0.140
5	2	1	88	6	5	6.0	0.7	131	27.6	16.8	11.6	8.0	0.32	0.36	12.0	1.1	147	0.091
6	2	1	88	6	6	6.0	0.7	120	27.6	14.4	7.2	8.0	0.28	0.24	12.4	1.1	149	0.077
7	2	1	88	6	7	6.0	1.1	147	35.2	22.0	8.4	4.8	0.24	0.48	14.8	0.9	177	0.105
8	2	1	88	6	8	6.0	1.0	160	38.8	19.6	7.6	4.8	0.20	0.36	16.8	1.2	212	0.113
9	3	2	88	6	9	6.3	0.9	420	9.2	24.8	20.0	5.6	0.80	0.92	8.0	13.6	50	0.070
10	3	2	88	6	10	6.3	0.9	347	12.8	21.2	15.2	8.0	0.80	0.88	7.6	10.4	52	0.042
11	3	2	88	6	11	5.9	0.6	140	10.8	11.2	9.4	8.0	0.40	0.68	10.4	12.4	53	0.049
12	3	2	88	6	12	5.8	0.7	146	10.4	14.0	12.8	9.2	0.40	0.72	10.0	12.0	52	0.035
13	4	2	88	6	13	4.9	1.3	78	9.2	11.6	8.0	8.4	0.12	0.28	21.6	7.6	58	0.049
14	4	2	88	6	14	5.8	1.1	258	11.6	19.6	11.6	8.8	0.08	0.72	13.6	9.2	63	0.035
15	4	2	88	6	15	6.1	0.5	236	16.4	15.6	16.8	7.6	0.44	0.44	8.8	8.8	63	0.021
16	4	2	88	6	16	6.3	0.8	439	10.0	19.2	8.4	5.6	0.48	0.68	6.0	8.8	52	0.021
17	1	1	88	10	1	6.4	1.2	520	73.2	54.4	14.8	12.0	0.36	0.56	15.2	3.0	368	0.158
18	1	1	88	10	2	6.5	1.1	500	66.4	43.2	12.0	10.0	0.40	0.52	15.2	2.6	340	0.133
19	1	1	88	10	3	6.7	1.2	524	61.6	49.2	7.2	10.0	0.40	0.32	13.6	2.2	324	0.113
20	1	1	88	10	4	6.5	1.1	480	68.4	38.0	8.0	9.6	0.40	0.88	15.2	2.6	356	0.155
21	2	1	88	10	5	5.6	0.8	58	15.6	7.6	6.8	4.0	0.24	0.32	11.2	1.0	148	0.134
22	2	1	88	10	6	5.6	0.9	65	17.2	9.2	7.2	4.8	0.24	0.88	12.4	1.2	173	0.141
23	2	1	88	10	7	5.7	0.9	63	15.6	8.8	6.4	6.0	0.20	0.48	11.6	1.1	166	0.140
24	2	1	88	10	8	5.7	0.9	79	20.0	9.2	8.0	8.8	0.20	0.56	12.4	1.3	178	0.162
25	3	2	88	10	9	6.6	0.4	500	15.6	19.6	19.2	25.2	0.88	0.72	13.2	7.6	83	0.070
26	3	2	88	10	10	6.8	0.3	260	8.0	9.2	8.4	9.2	0.42	0.40	8.0	3.6	40	0.077
27	3	2	88	10	11	6.6	0.5	274	8.0	12.0	11.6	9.6	0.48	0.48	6.8	4.4	38	0.077
28	3	2	88	10	12	6.7	0.3	268	9.2	10.8	8.8	10.0	0.44	0.64	8.0	4.4	41	0.070
29	4	2	88	10	13	6.5	0.5	281	8.8	12.8	10.0	4.8	0.52	0.60	7.6	4.4	44	0.056
30	4	2	88	10	14	6.6	0.4	256	8.4	10.4	9.2	5.2	0.46	1.08	8.4	4.4	44	0.077
31	4	2	88	10	15	6.6	0.5	256	9.2	15.2	10.8	6.0	0.48	0.56	7.6	4.8	41	0.049
32	4	2	88	10	16	6.5	0.5	272	11.6	15.6	11.6	10.0	0.48	0.40	8.0	4.8	64	0.091
33	1	1	89	3	1	5.9	0.7	212	19.2	13.2	10.0	8.4	0.32	0.44	11.2	1.7	154	0.091
34	1	1	89	3	2	6.0	1.1	269	24.8	15.2	12.8	6.8	0.24	0.28	11.6	3.0	208	0.056
35	1	1	89	3	3	5.7	1.0	150	10.4	15.6	10.0	8.4	0.08	0.60	14.0	1.2	136	0.070
36	1	1	89	3	4	5.9	0.9	98	42.8	14.4	16.0	7.2	0.04	0.28	15.2	3.4	235	0.084
37	1	1	89	3	5	6.0	1.3	227	13.2	22.0	9.6	8.8	0.04	0.28	14.0	1.5	156	0.098
38	2	1	89	3	6	5.4	1.0	45	13.6	6.4	8.0	5.2	0.28	0.48	15.2	1.2	120	0.119
39	2	1	89	3	7	5.4	0.9	56	14.0	8.0	8.8	4.8	0.24	0.48	15.2	1.3	146	0.056
40	2	1	89	3	8	5.5	0.7	84	21.2	6.4	7.2	6.0	0.24	1.32	13.6	1.8	121	0.084
41	2	1	89	3	9	5.7	0.9	118	23.2	8.4	8.4	4.8	0.24	0.68	14.0	1.2	149	0.111
42	3	2	89	3	10	5.1	2.2	97	13.6	26.4	18.8	4.8	0.16	0.80	32.0	5.6	114	0.084
43	3	2	89	3	11	5.4	1.2	132	6.0	19.6	18.0	4.8	0.08	0.72	14.4	4.8	62	0.049
44	3	2	89	3	12	6.1	1.3	506	9.2	31.2	35.6	7.6	0.08	0.48	7.6	6.8	62	0.042
45	4	2	89	3	13	5.9	1.3	336	10.4	27.2	18.4	9.2	0.88	0.88	9.2	9.6	93	0.049
46	4	2	89	3	14	6.4	1.2	472	21.6	67.2	38.0	10.4	0.96	0.96	5.6	9.6	160	0.056
47	4	2	89	3	15	5.9	1.1	341	10.4	26.8	22.0	8.4	0.96	0.76	8.8	6.8	91	0.097
48	1	1	89	5	1	7.3	0.9	204	53.8	27.7	31.4	11.1	1.80	1.23	11.2	3.2	172	0.377
49	1	1	89	5	2	5.9	1.4	122	32.4	10.2	13.6	8.9	0.82	0.94	10.8	2.0	169	0.091
50	1	1	89	5	3	6.3	1.1	395	17.2	34.6	10.0	6.8	0.52	0.69	7.1	2.2	115	0.063
51	1	1	89	5	4	6.0	2.0	270	78.8	41.5	30.4	12.4	0.39	1.26	14.8	5.3	330	0.181
52	1	1	89	5	5	6.0	1.1	158	12.5	27.8	14.8	8.9	0.27	0.48	10.2	1.7	108	0.063
53	1	1	89	5	6	5.9	1.2	164	10.3	22.9	10.9	7.8	0.24	0.30	10.0	2.1	96	0.070
54	1	1	89	5	7	5.4	1.2	41	9.3	6.4	9.0	46.7	0.19	0.63	11.8	1.1	76	0.070
55	1	1	89	5	8	5.9	1.4	180	20.2	33.1	8.0	9.4	0.19	0.95	11.0	2.0	114	0.063
56	1	1	89	5	9	5.6	1.5	105	29.5	20.0	17.5	8.6	0.21	0.30	12.8	4.4	178	0.090
57	2	1	89	5	10	5.5	0.9	60	8.6	10.9	8.8	7.8	0.26	0.40	9.7	1.2	80	0.072
58	2	1	89	5	11	6.5	1.3	124	16.5	22.4	11.5	7.3	0.22	0.43	11.2	2.2	107	0.097
59	2	1	89	5	12	6.0	1.1	150	27.9	15.9	14.4	6.4	0.21	0.52	11.1	1.7	130	0.059
60	3	2	89	5	13	5.6	1.1	231	15.8	31.4	22.3	5.9	1.05	1.50	13.0	14.1	58	0.039
61	3	2	89	5	14	5.8	1.1	147	8.9	24.5	47.4	6.4	0.65	0.87	11.2	17.5	50	0.098
62	3	2	89	5	15	5.3	0.9	85	8.2	16.4	15.1	6.8	0.45	0.59	13.4	11.1	45	0.078
63	4	2	89	5	16	4.9	1.4	84	8.1	22.5	17.6	6.5	0.19	1.24	13.4	15.6	40	0.046
64	4	2	89	5	17	5.3	1.1	151	10.7	33.4	23.0	9.7	0.20	1.34	12.7	12.5	37	0.039

65	4	2	89	5	18	5.3	1.8	230	7.4	35.9	35.0	11.9	0.32	0.83	13.8	20.7	69	0.046
66	1	1	89	6	1	5.6	1.3	207	21.8	21.8	11.5	10.0	0.25	1.12	10.2	2.9	118	0.065
67	1	1	89	6	2	6.0	1.1	284	23.1	28.3	8.0	6.5	0.24	1.37	9.1	1.9	130	0.078
68	1	1	89	6	3	6.2	0.9	264	25.1	53.1	13.7	11.3	0.27	0.92	7.6	1.3	117	0.071
69	1	1	89	6	4	5.7	2.0	370	72.4	57.4	29.2	8.4	0.15	1.05	12.6	4.4	282	0.131
70	1	1	89	6	5	5.8	1.2	106	10.4	29.0	12.9	6.8	0.15	0.64	9.4	1.6	64	0.053
71	1	1	89	6	6	5.9	0.9	128	7.6	20.1	8.8	6.5	0.12	0.44	8.7	0.7	74	0.029
72	1	1	89	6	7	5.0	1.2	54	9.3	8.0	6.8	9.4	0.12	0.70	12.7	1.1	93	0.065
73	1	1	89	6	8	5.1	1.4	89	41.5	15.1	17.2	6.5	0.10	0.79	14.7	3.1	246	0.070
74	1	1	89	6	9	5.2	1.2	66	21.6	13.6	16.9	7.6	0.10	1.14	13.8	1.7	146	0.041
75	2	1	89	6	10	5.5	0.8	50	9.5	10.6	8.0	5.7	0.21	0.66	9.1	0.9	64	0.018
76	2	1	89	6	11	5.3	1.2	77	21.4	15.0	10.2	5.7	0.21	1.94	11.2	2.4	110	0.018
77	2	1	89	6	12	5.3	2.0	72	25.7	9.2	14.6	5.7	0.17	0.56	6.3	2.3	192	0.047
78	3	2	89	6	13	4.9	1.4	160	12.1	38.6	34.6	5.4	0.16	2.25	14.5	24.3	53	0.023
79	3	2	89	6	14	5.3	1.2	303	10.6	23.1	45.6	6.5	0.12	0.48	10.5	16.2	59	0.023
80	3	2	89	6	15	4.9	1.2	193	7.6	22.0	12.5	7.2	0.20	1.20	13.0	13.2	68	0.023
81	4	2	89	6	16	5.4	1.1	375	16.1	35.7	39.3	6.5	0.38	1.57	10.7	23.6	62	0.012
82	4	2	89	6	17	4.9	1.4	220	11.2	32.9	15.4	7.0	0.73	1.15	12.8	23.1	73	0.017
83	4	2	89	6	18	5.2	1.8	467	9.2	47.7	20.0	7.0	0.79	1.04	7.8	12.2	92	0.053
84	1	1	89	8	1	5.7	1.3	269	26.8	27.3	19.4	4.9	0.30	1.11	9.3	2.9	139	0.035
85	1	1	89	8	2	5.8	1.0	172	18.4	18.1	17.5	4.6	0.26	0.44	9.1	1.4	104	0.070
86	1	1	89	8	3	6.0	1.0	172	18.5	23.1	9.3	4.9	0.21	1.56	8.8	2.0	104	0.023
87	1	1	89	8	4	5.8	2.2	209	42.3	38.6	8.4	8.1	0.13	0.49	11.4	3.9	226	0.082
88	1	1	89	8	5	5.8	0.8	87	6.4	17.4	13.0	4.9	0.07	0.33	6.0	0.7	54	0.041
89	1	1	89	8	6	5.5	1.2	135	12.2	20.4	19.6	7.3	0.12	0.44	10.7	2.1	87	0.035
90	1	1	89	8	7	5.3	1.2	28	8.4	4.8	7.3	4.9	0.10	0.48	11.0	1.2	71	0.047
91	1	1	89	8	8	5.8	1.0	142	25.3	25.2	6.2	8.0	0.13	0.57	11.9	1.9	140	0.059
92	1	1	89	8	9	5.7	1.0	34	7.7	5.2	5.1	5.1	0.08	0.28	11.0	0.5	88	0.059
93	2	1	89	8	10	5.8	1.0	122	9.3	13.4	6.6	5.1	0.30	0.37	8.2	0.8	77	0.053
94	2	1	89	8	11	5.8	1.0	113	12.4	21.0	10.0	6.1	0.14	0.39	7.7	1.0	68	0.076
95	2	1	89	8	12	5.6	1.0	31	13.2	4.3	6.6	4.9	0.18	0.48	12.3	1.1	82	0.082
96	3	2	89	8	13	5.6	1.4	190	17.6	57.1	18.5	5.4	0.19	2.50	12.6	21.9	48	0.020
97	3	2	89	8	14	5.4	1.0	89	5.6	17.4	13.0	5.9	0.12	0.95	13.0	11.4	35	0.054
98	3	2	89	8	15	4.8	2.1	108	14.4	33.6	26.2	8.0	0.18	0.94	21.6	7.5	122	0.047
99	4	2	89	8	16	5.3	1.0	144	8.9	23.6	10.5	7.5	0.68	0.89	10.8	10.9	48	0.250
100	4	2	89	8	17	5.5	1.6	547	11.9	34.4	17.0	8.4	1.00	1.12	10.3	30.4	81	0.081
101	4	2	89	8	18	5.3	1.5	213	11.0	28.7	13.7	7.6	0.55	0.62	11.2	17.0	88	0.013
102	1	1	89	10	1	5.9	0.8	210	15.8	16.7	11.5	5.3	0.20	0.73	7.5	1.6	118	0.047
103	1	1	89	10	2	6.1	0.8	129	13.0	10.0	37.2	5.9	0.18	0.59	9.0	0.7	115	0.047
104	1	1	89	10	3	6.0	1.1	192	18.7	19.7	9.0	5.7	0.43	0.78	9.9	2.1	144	0.108
105	1	1	89	10	4	5.6	1.8	134	39.4	22.8	24.6	7.0	0.10	0.41	12.4	1.8	237	0.054
106	1	1	89	10	5	5.6	1.4	107	35.3	28.1	14.6	7.0	0.18	0.73	11.8	2.5	232	0.087
107	1	1	89	10	6	5.9	1.0	219	7.5	42.7	6.4	5.9	0.09	0.84	8.6	1.2	132	0.054
108	1	1	89	10	7	4.9	1.0	53	8.2	10.2	16.1	8.6	0.08	0.75	10.1	1.3	101	0.080
109	1	1	89	10	8	5.6	1.0	124	13.9	26.8	8.6	6.5	0.08	0.81	8.8	1.8	100	0.088
110	1	1	89	10	9	5.5	1.0	85	9.7	12.9	6.2	6.8	0.08	0.72	9.9	1.0	78	0.342
111	2	1	89	10	10	5.4	0.5	75	18.9	10.7	7.6	6.5	0.14	1.31	11.2	0.9	107	0.007
112	2	1	89	10	11	4.8	1.2	70	16.7	15.1	15.2	5.4	0.20	1.57	11.3	1.2	145	0.013
113	2	1	89	10	12	5.6	1.0	83	15.7	15.4	20.0	5.4	0.23	1.62	9.5	1.6	126	0.007
114	3	2	89	10	13	5.3	1.3	212	15.9	42.0	20.6	5.3	0.18	2.80	15.4	22.0	59	0.067
115	3	2	89	10	14	5.6	1.2	118	6.3	33.2	30.2	8.6	0.11	1.92	8.8	10.2	32	0.020
116	3	2	89	10	15	5.0	1.8	278	25.3	58.7	24.0	5.9	0.20	1.95	15.1	19.0	81	0.357
117	4	2	89	10	16	5.0	0.9	89	13.2	28.6	39.0	6.5	0.50	1.41	12.2	12.0	67	0.457
118	4	2	89	10	17	5.0	1.0	156	10.5	22.7	21.8	6.8	0.60	1.46	11.1	18.8	68	0.047
119	4	2	89	10	18	5.5	1.4	676	13.0	38.8	14.8	8.4	0.61	1.60	7.6	8.7	63	0.115

FORAGE DATA CODES

OB = Observation number (1-119).

PA = Pasture (1-4).

LO = Location: 1. Bronson.
2. Williston.

YR = Year (88 and 89).

MT = Month: 3. March.
5. May.
6. June.
8. August.
10. October.

OS = Sample observation number.

Macrominerals (Dry matter basis), and Crude protein.

Ca = Calcium, %.
P = Phosphorus, %.
K = Potassium, %.
Mg = Magnesium, %.
Na = Sodium, %.
CP = Crude protein, %.

Trace elements (Dry matter basis)

Cu = Copper, ppm.
Zn = Zinc, ppm.
Fe = Iron, ppm.
Mn = Manganese, ppm.
Co = Cobalt, ppm.
Mo = Molydenum, ppm.
Sel = Selenium, ppm.

F O R A G E   D A T A

OB	PA	LO	YR	MT	OS	Ca	P	K	Mg	Na	CP	Cu	Zn	Fe	Mn	Co	Mo	Sel
1	1	1	88	6	1	0.71	0.24	1.48	0.35	0.048	11.2	6.38	33.2	230	83	0.050	0.521	0.026
2	1	1	88	6	2	0.70	0.22	1.39	0.35	0.034	13.4	5.86	30.2	190	73	0.052	0.395	0.063
3	1	1	88	6	3	0.63	0.11	1.36	0.19	0.039	9.9	4.54	30.6	219	51	0.068	0.459	0.064
4	1	1	88	6	4	0.63	0.19	1.40	0.18	0.047	10.5	4.89	32.2	156	46	0.040	0.568	0.039
5	2	1	88	6	5	0.76	0.23	1.17	0.39	0.043	11.7	7.24	34.9	103	70	0.040	0.718	0.081
6	2	1	88	6	6	0.76	0.28	1.32	0.42	0.038	13.1	7.29	33.6	115	66	0.048	0.732	0.055
7	2	1	88	6	7	0.77	0.25	1.17	0.43	0.037	15.4	8.78	30.6	101	38	0.033	0.910	0.091
8	2	1	88	6	8	0.54	0.27	1.27	0.44	0.036	15.1	9.38	32.8	113	45	0.042	0.698	0.051
9	3	2	88	6	9	0.90	0.20	0.98	0.25	0.057	11.0	4.82	39.2	205	344	0.147	0.280	0.059
10	3	2	88	6	10	1.08	0.19	0.76	0.27	0.039	12.9	5.15	34.2	243	233	0.162	0.440	0.054
11	3	2	88	6	11	0.73	0.19	1.04	0.24	0.040	11.9	5.50	34.1	228	122	0.130	0.355	0.067
12	3	2	88	6	12	0.71	0.18	0.93	0.23	0.029	10.2	6.90	38.5	224	170	0.126	0.597	0.062
13	4	2	88	6	13	0.54	0.17	1.19	0.14	0.027	9.8	5.88	39.1	214	141	0.114	0.447	0.044
14	4	2	88	6	14	0.31	0.22	1.16	0.10	0.020	10.2	4.84	53.0	174	86	0.068	0.190	0.078
15	4	2	88	6	15	0.50	0.14	0.94	0.13	0.024	9.4	2.66	44.1	151	326	0.093	0.587	0.052
16	4	2	88	6	16	0.58	0.16	1.22	0.17	0.027	10.1	3.53	38.1	121	343	0.095	0.600	0.074
17	1	1	88	10	1	0.50	0.08	0.23	0.37	0.019	8.2	1.64	10.3	142	59	0.066	0.401	0.092
18	1	1	88	10	2	0.41	0.08	0.18	0.34	0.024	9.1	2.62	11.1	106	79	0.065	0.478	0.077
19	1	1	88	10	3	0.38	0.07	0.15	0.28	0.007	9.3	1.11	8.3	44	47	0.058	0.408	0.138
20	1	1	88	10	4	0.41	0.07	0.20	0.30	0.010	9.5	1.68	11.8	81	70	0.060	0.434	0.123
21	2	1	88	10	5	0.35	0.07	0.25	0.21	0.016	3.6	2.66	17.8	111	88	0.059	0.327	0.046
22	2	1	88	10	6	0.29	0.05	0.27	0.20	0.027	3.0	3.23	12.6	67	75	0.047	0.280	0.077
23	2	1	88	10	7	0.36	0.06	0.25	0.23	0.036	3.6	3.24	15.1	72	77	0.046	0.330	0.130
24	2	1	88	10	8	0.31	0.06	0.27	0.21	0.029	3.4	3.58	13.4	62	78	0.046	0.316	0.061
25	3	2	88	10	9	0.38	0.09	0.29	0.20	0.020	4.4	2.57	16.7	98	79	0.080	0.302	0.054
26	3	2	88	10	10	0.29	0.09	0.35	0.18	0.020	4.8	1.51	14.2	229	100	0.099	0.306	0.092
27	3	2	88	10	11	0.39	0.10	0.38	0.23	0.012	5.8	1.57	16.7	244	78	0.083	0.310	0.038
28	3	2	88	10	12	0.32	0.07	0.35	0.20	0.009	5.9	2.00	14.6	89	97	0.075	0.275	0.046
29	4	2	88	10	13	0.44	0.08	0.27	0.21	0.020	6.2	3.16	18.2	105	78	0.081	0.263	0.061
30	4	2	88	10	14	0.32	0.10	0.47	0.23	0.031	5.0	2.53	17.6	171	90	0.088	0.266	0.061
31	4	2	88	10	15	0.44	0.09	0.28	0.22	0.013	7.1	1.75	16.5	104	101	0.086	0.295	0.061
32	4	2	88	10	16	0.43	0.10	0.50	0.23	0.031	6.7	2.44	21.3	154	80	0.104	0.274	0.085
33	1	1	89	3	1	0.52	0.25	1.30	0.28	0.031	14.2	10.30	31.4	260	69	0.075	1.027	0.077
34	1	1	89	3	2	0.51	0.25	1.52	0.27	0.034	14.1	14.50	25.1	217	71	0.071	0.542	0.031
35	1	1	89	3	3	0.51	0.22	1.09	0.31	0.045	14.4	4.50	20.3	223	64	0.062	0.374	0.061
36	1	1	89	3	4	0.52	0.23	1.17	0.32	0.054	16.6	7.60	20.5	192	77	0.061	0.594	0.061
37	1	1	89	3	5	0.59	0.23	1.04	0.26	0.039	13.4	4.70	19.6	131	149	0.056	0.507	0.076
38	2	1	89	3	6	0.51	0.21	0.92	0.24	0.047	18.0	9.00	21.9	117	136	0.061	0.485	0.046
39	2	1	89	3	7	0.44	0.19	0.99	0.23	0.041	16.1	7.20	17.9	112	94	0.050	0.135	0.084
40	2	1	89	3	8	0.41	0.18	0.86	0.23	0.027	16.8	7.00	18.3	97	90	0.048	0.440	0.061
41	2	1	89	3	9	0.35	0.17	0.56	0.16	0.035	12.5	6.50	24.5	85	61	0.045	0.585	0.069
42	3	2	89	3	10	0.41	0.23	1.02	0.25	0.046	8.2	4.90	18.2	72	303	0.066	0.219	0.054
43	3	2	89	3	11	0.41	0.23	1.47	0.22	0.034	8.3	7.00	23.1	91	240	0.063	0.207	0.038
44	3	2	89	3	12	0.44	0.21	1.45	0.23	0.023	9.6	6.30	20.7	64	207	0.069	0.272	0.061
45	4	2	89	3	13	0.34	0.19	1.40	0.30	0.030	12.1	3.50	42.5	189	240	0.109	0.228	0.031
46	4	2	89	3	14	0.31	0.18	1.18	0.19	0.035	11.2	4.80	22.3	28	129	0.094	0.378	0.018
47	4	2	89	3	15	0.38	0.22	1.50	0.25	0.041	11.8	4.30	30.8	87	152	0.078	0.131	0.049
48	1	1	89	5	1	0.52	0.19	1.11	0.27	0.041	11.4	7.40	25.8	235	58	0.022	0.296	0.031
49	1	1	89	5	2	0.52	0.20	1.38	0.27	0.051	11.5	7.70	28.1	233	53	0.027	0.269	0.049
50	1	1	89	5	3	0.57	0.16	0.77	0.34	0.026	11.4	5.40	17.5	213	42	0.026	0.300	0.086
51	1	1	89	5	4	0.55	0.20	1.17	0.29	0.015	12.1	3.00	16.3	71	56	0.015	0.154	0.018
52	1	1	89	5	5	0.59	0.15	0.96	0.31	0.027	13.6	4.40	16.2	132	68	0.025	0.125	0.018
53	1	1	89	5	6	0.59	0.14	0.81	0.29	0.040	12.8	5.00	18.1	258	84	0.016	0.102	0.012
54	1	1	89	5	7	0.44	0.14	0.82	0.13	0.040	11.0	2.60	16.5	153	105	0.018	0.123	0.031
55	1	1	89	5	8	0.59	0.18	0.75	0.22	0.037	11.7	3.10	18.0	93	58	0.021	0.447	0.086
56	1	1	89	5	9	0.51	0.16	1.03	0.18	0.034	9.8	3.50	16.9	58	113	0.043	0.179	0.012
57	2	1	89	5	10	0.64	0.13	0.66	0.37	0.039	14.9	6.90	17.1	86	78	0.034	0.187	0.024
58	2	1	89	5	11	0.44	0.13	0.60	0.19	0.035	15.0	5.60	15.2	74	144	0.041	0.122	0.043
59	2	1	89	5	12	0.55	0.16	0.94	0.29	0.031	12.5	6.30	21.2	62	72	0.031	0.271	0.037
60	3	2	89	5	13	0.50	0.19	1.23	0.21	0.029	12.8	5.20	27.2	151	235	0.054	0.092	0.055
61	3	2	89	5	14	0.38	0.14	0.63	0.17	0.021	9.2	3.40	17.6	109	212	0.037	0.132	0.104
62	3	2	89	5	15	0.55	0.13	0.73	0.24	0.035	9.2	3.70	14.1	100	299	0.042	0.018	0.031
63	4	2	89	5	16	0.48	0.20	1.69	0.24	0.036	13.4	7.10	37.6	83	164	0.080	0.319	0.031
64	4	2	89	5	17	0.46	0.16	1.38	0.23	0.026	11.6	5.40	22.9	78	154	0.053	0.304	0.043
65	4	2	89	5	18	0.36	0.16	1.53	0.25	0.044	9.5	6.20	23.8	94	257	0.061	0.042	0.049

66	1	1	89	6	1	0.33	0.19	1.12	0.31	0.033	8.1	7.30	22.4	117	49	0.047	0.770	0.012
67	1	1	89	6	2	0.05	0.16	0.16	0.05	0.005	11.2	8.30	19.1	25	38	0.043	1.405	0.024
68	1	1	89	6	3	0.10	0.22	0.34	0.08	0.041	8.8	6.00	20.2	123	34	0.039	1.474	0.018
69	1	1	89	6	4	0.29	0.23	1.26	0.27	0.010	6.8	3.00	16.2	35	54	0.040	1.420	0.031
70	1	1	89	6	5	0.32	0.20	0.88	0.29	0.005	7.2	5.70	13.4	19	64	0.038	1.132	0.012
71	1	1	89	6	6	0.20	0.15	0.68	0.17	0.018	7.0	2.90	13.1	36	36	0.031	1.126	0.071
72	1	1	89	6	7	0.39	0.21	0.83	0.29	0.018	6.9	7.20	19.2	41	102	0.038	0.054	0.058
73	1	1	89	6	8	0.22	0.25	0.56	0.18	0.034	11.5	6.80	16.8	127	91	0.033	1.100	0.039
74	1	1	89	6	9	0.34	0.22	1.11	0.33	0.022	9.3	5.40	17.7	90	95	0.039	0.306	0.064
75	2	1	89	6	10	0.28	0.16	0.32	0.15	0.033	7.0	6.90	14.1	51	79	0.033	0.670	0.077
76	2	1	89	6	11	0.28	0.18	0.92	0.19	0.021	5.9	5.70	15.9	68	94	0.032	1.522	0.039
77	2	1	89	6	12	0.32	0.18	0.88	0.16	0.033	7.0	5.10	20.9	64	102	0.038	0.977	0.045
78	3	2	89	6	13	0.30	0.25	1.65	0.24	0.023	9.5	8.20	29.0	101	269	0.085	1.151	0.026
79	3	2	89	6	14	0.38	0.23	1.15	0.26	0.026	8.8	7.00	18.6	89	205	0.062	0.200	0.039
80	3	2	89	6	15	0.32	0.20	1.00	0.30	0.025	8.1	5.50	15.7	46	245	0.055	0.278	0.026
81	4	2	89	6	16	0.24	0.17	1.31	0.18	0.026	5.9	5.70	24.3	46	158	0.087	0.560	0.026
82	4	2	89	6	17	0.30	0.13	0.64	0.31	0.007	8.8	5.30	16.8	25	139	0.095	0.150	0.019
83	4	2	89	6	18	0.37	0.11	1.56	0.24	0.034	5.0	3.90	13.8	24	231	0.105	0.177	0.077
84	1	1	89	8	1	0.30	0.19	1.10	0.29	0.026	6.5	7.40	27.6	82	42	0.095	0.896	0.039
85	1	1	89	8	2	0.34	0.14	0.81	0.32	0.045	6.1	3.90	17.1	105	38	0.050	1.172	0.064
86	1	1	89	8	3	0.42	0.17	0.85	0.31	0.018	7.2	5.40	15.8	54	41	0.028	0.589	0.026
87	1	1	89	8	4	0.36	0.18	1.01	0.24	0.020	8.6	4.20	14.0	122	51	0.033	0.576	0.052
88	1	1	89	8	5	0.47	0.16	1.08	0.25	0.023	7.3	3.90	12.1	70	48	0.034	0.867	0.032
89	1	1	89	8	6	0.40	0.14	1.00	0.25	0.015	6.8	3.90	10.8	18	57	0.013	0.511	0.026
90	1	1	89	8	7	0.32	0.15	1.16	0.19	0.013	9.2	6.40	15.7	45	72	0.021	1.183	0.077
91	1	1	89	8	8	0.40	0.18	0.97	0.29	0.025	8.7	4.10	13.4	66	38	0.043	0.723	0.064
92	1	1	89	8	9	0.35	0.15	1.16	0.19	0.019	10.3	7.00	15.8	50	52	0.022	1.078	0.084
93	2	1	89	8	10	0.45	0.14	0.76	0.23	0.012	7.4	4.00	10.4	55	50	0.022	1.048	0.058
94	2	1	89	8	11	0.39	0.14	0.79	0.24	0.009	2.1	4.10	11.1	72	45	0.022	0.759	0.077
95	2	1	89	8	12	0.45	0.14	0.56	0.24	0.018	3.0	4.10	11.1	35	73	0.020	0.510	0.071
96	3	2	89	8	13	0.26	0.21	1.33	0.25	0.009	4.8	10.00	24.2	18	95	0.039	0.137	0.019
97	3	2	89	8	14	0.35	0.18	0.82	0.25	0.020	3.7	4.70	16.0	49	201	0.030	0.108	0.019
98	3	2	89	8	15	0.31	0.16	1.05	0.27	0.034	5.3	6.20	15.9	66	148	0.045	0.090	0.032
99	4	2	89	8	16	0.36	0.16	1.10	0.21	0.016	4.4	4.90	16.3	29	223	0.070	0.021	0.071
100	4	2	89	8	17	0.29	0.14	1.00	0.20	0.018	6.0	4.60	14.3	30	231	0.070	0.564	0.026
101	4	2	89	8	18	0.49	0.12	0.76	0.22	0.014	5.2	2.80	9.8	29	117	0.043	0.548	0.045
102	1	1	89	10	1	0.48	0.19	0.17	0.21	0.016	6.5	1.50	9.8	134	49	0.004	0.228	0.104
103	1	1	89	10	2	0.45	0.19	0.14	0.25	0.026	9.2	2.60	11.5	75	76	0.012	0.295	0.111
104	1	1	89	10	3	0.44	0.17	0.17	0.21	0.009	7.5	1.20	10.3	75	44	0.014	0.275	0.105
105	1	1	89	10	4	0.50	0.24	0.18	0.27	0.011	8.5	1.90	12.1	74	73	0.011	0.286	0.085
106	1	1	89	10	5	0.41	0.20	0.18	0.16	0.014	7.3	2.70	18.4	117	80	0.009	0.247	0.085
107	1	1	89	10	6	0.36	0.18	0.25	0.16	0.027	6.3	3.30	13.5	48	72	0.013	0.177	0.091
108	1	1	89	10	7	0.42	0.22	0.26	0.18	0.034	6.0	3.30	16.2	54	73	0.028	0.189	0.065
109	1	1	89	10	8	0.39	0.20	0.27	0.17	0.030	7.0	3.40	15.4	65	72	0.040	0.310	0.098
110	1	1	89	10	9	0.43	0.21	0.24	0.16	0.017	8.3	2.60	18.5	90	76	0.014	0.236	0.065
111	2	1	89	10	10	0.42	0.16	0.36	0.17	0.018	6.1	1.50	13.5	192	92	0.018	0.309	0.104
112	2	1	89	10	11	0.47	0.18	0.31	0.18	0.011	6.4	1.70	19.4	253	77	0.028	0.303	0.110
113	2	1	89	10	12	0.39	0.16	0.29	0.16	0.012	6.8	2.30	15.9	119	94	0.008	0.324	0.117
114	3	2	89	10	13	0.48	0.25	0.23	0.16	0.020	9.5	9.00	18.8	88	72	0.021	0.203	0.059
115	3	2	89	10	14	0.37	0.26	0.39	0.17	0.031	9.2	1.70	16.0	163	83	0.017	0.196	0.078
116	3	2	89	10	15	0.53	0.22	0.28	0.19	0.013	6.1	1.80	15.6	101	96	0.040	0.100	0.150
117	4	2	89	10	16	0.38	0.26	0.36	0.14	0.035	5.8	1.40	17.0	157	63	0.031	0.135	0.052
118	4	2	89	10	17	0.55	0.19	0.45	0.27	0.021	6.2	5.60	20.6	63	41	0.034	0.195	0.059
119	4	2	89	10	18	0.57	0.19	0.43	0.19	0.030	5.8	5.90	16.5	89	59	0.013	0.205	0.078

SERUM AND HAIR COWS DATA CODES
(Experiments 1 and 2)

OB = Observation number (1-333).

LO = Location: 1. Bronson.
2. Williston.

Se = Selenium: 1. Treated.
2. Control.

VE = Vitamin E: 1. Treated.
2. Control.

YR = Year (88 and 89).

MT = Month: 3. March.
6. June.
10. October.

OS = Sample observation number.

COW = Cow number.

Ca = Calcium, mg/dl.

P = Phosphorus, mg/dl.

Mg = Magnesium, mg/dl.

Cu = Copper, ppm.

Zn = Zinc, ppm.

Fe = Iron, ppm.

Sel = Selenium, ppm.

HSel = Hair selenium, ppm.

SERUM AND HAIR COWS DATA

OB	LO	Se	VE	MT	YR	OS	COW	Ca	P	MG	Cu	Zn	Fe	Sel	Vit	HSel
1	1	1	.	6	88	1	12	5.3	3.8	1.8	0.16	0.14	0.31	0.045	.	0.58
2	1	1	.	6	88	2	42	6.3	4.7	2.1	0.86	0.70	0.66	0.063	.	0.61
3	1	1	.	6	88	3	67	5.5	3.4	1.9	0.47	0.56	1.46	0.049	.	0.39
4	1	1	.	6	88	4	72	5.9	3.5	2.1	1.04	0.68	2.02	0.063	.	0.38
5	1	1	.	6	88	5	101	5.5	4.4	1.8	0.52	0.54	0.70	0.047	.	0.50
6	1	1	.	6	88	6	122	6.8	3.2	2.3	0.34	0.69	1.79	0.054	.	0.58
7	1	1	.	6	88	7	137	7.2	2.7	2.2	0.70	0.45	2.00	0.055	.	0.51
8	1	1	.	6	88	8	383	5.5	3.0	2.5	0.34	0.64	0.94	0.099	.	0.91
9	1	1	.	6	88	9	519	6.4	5.0	1.8	0.54	0.80	1.43	0.045	.	0.49
10	1	1	.	6	88	10	715	7.9	2.4	2.8	0.51	0.71	1.31	0.042	.	0.45
11	1	1	.	6	88	11	892	5.2	4.6	2.3	0.55	0.36	0.93	0.019	.	0.38
12	1	2	.	6	88	12	26	5.8	8.8	2.0	1.30	1.10	1.90	0.040	.	0.67
13	1	2	.	6	88	13	110	6.4	4.5	2.7	0.52	0.59	1.67	0.073	.	0.54
14	1	2	.	6	88	14	267	8.9	5.9	2.3	0.66	0.94	1.41	0.040	.	0.84
15	1	2	.	6	88	15	332	5.4	3.6	1.5	0.84	0.47	1.12	0.040	.	0.61
16	1	2	.	6	88	16	387	7.8	3.8	2.5	0.80	0.71	2.01	0.033	.	0.66
17	1	2	.	6	88	17	490	7.1	4.8	2.3	0.68	0.99	1.90	0.042	.	0.37
18	1	2	.	6	88	18	510	8.8	4.2	2.8	0.85	0.98	2.14	0.059	.	0.46
19	1	2	.	6	88	19	632	8.5	3.3	2.6	1.38	0.77	2.16	0.047	.	0.46
20	1	2	.	6	88	20	709	7.0	4.2	2.2	0.35	0.84	2.06	0.058	.	0.50
21	1	2	.	6	88	21	798	6.7	3.6	1.9	0.78	0.83	1.79	0.049	.	0.69
22	1	2	.	6	88	22	830	8.8	4.0	2.4	0.88	1.14	2.01	0.045	.	0.60
23	1	2	.	6	88	23	860	7.0	4.5	1.8	0.43	0.96	1.87	0.056	.	0.67
24	2	1	.	6	88	24	279	6.6	4.4	2.2	0.71	0.71	2.07	0.044	.	0.87
25	2	1	.	6	88	25	303	6.4	3.0	1.8	0.38	0.79	2.05	0.126	.	0.34
26	2	1	.	6	88	26	353	6.8	4.6	2.5	0.69	0.84	1.80	0.070	.	0.68
27	2	1	.	6	88	27	389	4.4	2.3	1.6	0.60	0.37	1.32	0.058	.	0.58
28	2	1	.	6	88	28	449	6.9	5.1	2.2	0.88	0.71	2.00	0.028	.	.
29	2	1	.	6	88	29	483	5.7	3.3	1.1	0.48	0.69	0.84	0.066	.	0.49
30	2	1	.	6	88	30	490	7.8	4.3	2.1	0.61	0.58	1.51	0.058	.	0.37
31	2	1	.	6	88	31	507	7.0	3.8	2.1	0.30	0.82	1.27	0.055	.	0.66
32	2	1	.	6	88	32	716	6.4	3.8	1.9	0.51	0.62	1.59	0.051	.	0.80
33	2	1	.	6	88	33	887	6.9	1.7	1.8	0.70	0.85	1.51	0.054	.	0.49
34	2	1	.	6	88	34	894	7.3	4.5	2.0	0.92	0.78	0.99	0.026	.	0.83
35	2	1	.	6	88	35	1022	7.3	5.7	2.2	0.57	0.84	0.80	0.032	.	0.52
36	2	2	.	6	88	36	250	8.1	7.0	1.5	1.22	0.66	.	0.022	.	.
37	2	2	.	6	88	37	294	6.2	5.0	2.4	1.14	0.88	1.25	0.058	.	0.32
38	2	2	.	6	88	38	345	5.5	3.0	2.6	0.68	0.74	1.18	0.062	.	0.83
39	2	2	.	6	88	39	491	10.1	3.3	2.9	1.06	0.96	1.86	0.048	.	0.61
40	2	2	.	6	88	40	523	4.3	4.4	2.2	0.44	0.78	0.89	0.057	.	0.73
41	2	2	.	6	88	41	780	4.3	1.7	1.4	0.16	0.50	0.49	0.060	.	0.70
42	2	2	.	6	88	42	784	5.7	4.2	1.4	0.40	0.71	1.21	0.042	.	0.48
43	2	2	.	6	88	43	818	3.9	1.4	1.6	0.46	0.34	0.62	0.044	.	0.42
44	2	2	.	6	88	44	844	5.6	3.8	2.3	0.66	0.70	1.16	0.030	.	0.47
45	2	2	.	6	88	45	851	5.9	3.7	1.8	0.47	0.85	2.09	0.022	.	.
46	2	2	.	6	88	46	874	5.2	4.4	1.7	0.62	0.53	1.34	0.085	.	0.28
47	2	2	.	6	88	47	897	8.1	4.9	1.9	0.65	0.98	1.20	0.042	.	0.55
48	2	2	.	6	88	48	1089	5.7	3.9	2.4	0.99	0.57	1.09	0.086	.	0.60
49	1	1	.	10	88	49	12	9.7	3.3	2.3	0.44	0.75	0.35	0.113	.	0.84
50	1	1	.	10	88	50	42	9.0	4.2	2.0	0.63	1.06	1.23	0.099	.	0.58
51	1	1	.	10	88	51	67	9.5	2.8	2.3	0.57	0.93	0.18	0.063	.	0.87
52	1	1	.	10	88	52	72	9.4	2.9	2.2	0.60	1.05	0.68	0.070	.	0.46
53	1	1	.	10	88	53	101	9.4	2.8	2.4	0.87	1.06	0.57	0.232	.	0.55
54	1	1	.	10	88	54	137	9.6	3.4	2.7	0.96	0.99	0.40	0.077	.	0.40
55	1	1	.	10	88	55	519	9.6	5.3	2.3	0.50	0.95	0.92	0.070	.	0.53
56	1	1	.	10	88	56	715	9.8	3.4	2.5	0.64	1.12	0.10	0.113	.	0.30
57	1	1	.	10	88	57	892	9.3	3.3	2.8	0.67	0.89	0.88	0.099	.	0.41
58	1	2	.	10	88	58	26	8.3	4.1	2.3	0.75	0.77	0.69	0.049	.	0.58
59	1	2	.	10	88	59	110	9.0	3.2	2.2	0.66	0.88	0.32	0.099	.	0.64
60	1	2	.	10	88	60	267	9.0	2.4	2.1	0.63	1.18	0.89	0.035	.	0.44
61	1	2	.	10	88	61	332	9.3	3.3	2.2	0.99	0.89	0.91	0.056	.	0.43
62	1	2	.	10	88	62	387	9.0	2.6	2.5	0.84	0.84	1.11	0.035	.	0.62
63	1	2	.	10	88	63	490	7.3	2.6	2.1	0.82	1.11	1.00	0.063	.	0.25
64	1	2	.	10	88	64	510	8.9	3.3	2.4	0.94	1.34	1.10	0.056	.	0.48

65	1	2	.	10	88	65	632	8.4	4.0	2.3	0.78	0.89	1.49	0.049	.	0.87
66	1	2	.	10	88	66	709	8.5	4.1	2.4	0.85	1.13	1.01	0.056	.	0.53
67	1	2	.	10	88	67	798	8.7	3.3	2.1	0.82	0.99	1.71	0.049	.	0.44
68	1	2	.	10	88	68	830	9.8	3.0	2.6	0.72	0.96	0.42	0.049	.	0.80
69	1	2	.	10	88	69	860	9.4	4.9	1.9	0.31	0.74	0.46	0.068	.	0.43
70	2	1	.	10	88	70	279	7.8	5.3	2.2	0.85	0.89	1.10	0.077	.	0.51
71	2	1	.	10	88	71	303	7.9	3.7	1.5	0.74	0.74	0.74	.	.	0.38
72	2	1	.	10	88	72	353	8.8	7.2	2.3	0.66	0.67	0.31	0.085	.	0.57
73	2	1	.	10	88	73	389	10.4	7.4	2.0	0.48	0.93	0.58	0.092	.	0.48
74	2	1	.	10	88	74	449	11.5	3.0	1.9	0.58	1.18	1.01	.	.	.
75	2	1	.	10	88	75	483	9.0	4.3	1.7	0.49	0.76	0.02	0.155	.	0.54
76	2	1	.	10	88	76	490	9.9	5.3	2.2	0.79	0.75	0.73	0.141	.	0.25
77	2	1	.	10	88	77	507	9.6	4.3	2.1	0.48	0.98	0.56	0.106	.	0.70
78	2	1	.	10	88	78	716	8.7	5.4	1.8	0.73	1.00	0.83	0.134	.	0.69
79	2	1	.	10	88	79	887	9.2	4.2	2.0	0.70	0.91	1.21	0.127	.	0.56
80	2	1	.	10	88	80	1022	9.2	2.5	2.4	0.51	0.95	0.80	0.148	.	0.58
81	2	2	.	10	88	81	250	9.8	3.2	2.3	0.66	0.90	0.42	.	.	.
82	2	2	.	10	88	82	294	8.0	2.6	2.8	0.89	0.96	0.70	0.102	.	0.29
83	2	2	.	10	88	83	345	7.5	3.8	2.6	0.76	0.93	0.81	0.062	.	0.39
84	2	2	.	10	88	84	491	8.1	4.9	2.2	0.94	0.68	0.13	0.056	.	0.41
85	2	2	.	10	88	85	523	7.0	2.6	2.5	0.54	0.94	0.37	0.056	.	0.33
86	2	2	.	10	88	86	780	8.7	2.0	2.2	0.76	0.86	0.30	0.051	.	0.47
87	2	2	.	10	88	87	839	7.5	3.0	2.1	0.64	0.80	0.50	0.056	.	0.60
88	2	2	.	10	88	88	844	7.9	3.8	2.4	0.41	0.82	0.26	0.062	.	0.26
89	2	2	.	10	88	89	874	8.3	1.7	2.3	0.93	1.50	0.09	0.051	.	0.21
90	2	2	.	10	88	90	897	8.0	2.1	2.3	0.67	0.93	0.33	0.079	.	0.29
91	2	2	.	10	88	91	937	8.3	3.2	2.3	0.62	0.80	1.19	0.034	.	0.66
92	2	2	.	10	88	92	941	8.3	2.8	1.9	0.76	0.82	0.19	0.034	.	.
93	1	1	.	3	89	1	53	8.4	3.5	1.8	0.88	0.54	2.21	0.096	.	0.31
94	1	1	1	3	89	2	82	8.5	3.3	2.4	0.83	0.57	2.64	0.175	7.1	1.13
95	1	1	1	3	89	3	105	8.7	4.1	2.1	0.78	0.93	2.12	0.124	3.6	0.72
96	1	1	1	3	89	4	139	8.4	2.5	1.8	1.12	0.56	3.11	0.209	5.0	0.89
97	1	1	1	3	89	5	141	8.3	3.6	1.7	0.80	0.63	3.24	0.136	4.1	0.79
98	1	1	1	3	89	6	155	8.0	3.8	1.9	0.99	0.42	3.06	0.045	0.7	0.61
99	1	1	1	3	89	7	207	8.5	2.8	2.0	0.96	0.81	3.91	0.120	0.9	1.01
100	1	1	1	3	89	8	210	7.8	2.3	1.5	1.11	0.54	3.19	0.075	2.9	0.47
101	1	1	1	3	89	9	273	8.0	3.3	1.7	0.56	0.86	3.90	0.120	4.9	0.80
102	1	1	1	3	89	10	699	7.9	2.6	1.9	1.07	0.57	2.32	0.105	5.9	0.45
103	1	1	2	3	89	11	50	8.6	2.6	2.4	0.87	0.67	1.98	0.107	4.4	1.03
104	1	1	2	3	89	12	78	8.3	3.8	1.8	0.71	0.64	2.12	0.124	5.1	0.79
105	1	1	2	3	89	13	101	8.2	3.0	1.6	1.00	0.74	3.70	0.203	.	0.54
106	1	1	2	3	89	14	189	8.3	5.0	1.8	0.85	0.63	3.72	0.263	4.1	0.61
107	1	1	2	3	89	15	212	8.1	3.6	1.8	1.22	0.53	3.19	0.083	5.2	0.48
108	1	1	2	3	89	16	222	8.1	2.5	1.8	0.95	0.63	3.14	0.053	4.7	0.67
109	1	1	2	3	89	17	301	7.9	2.5	2.1	0.76	0.55	3.08	0.128	5.5	1.01
110	1	1	2	3	89	18	378	7.4	3.0	2.5	0.76	0.59	2.36	0.113	3.2	0.56
111	1	1	2	3	89	19	519	8.0	2.9	2.2	0.91	0.46	2.12	0.158	4.9	.
112	1	1	2	3	89	20	527	8.2	2.4	2.0	1.16	0.72	2.42	0.128	4.6	0.36
113	1	2	1	3	89	21	151	8.2	4.1	2.2	0.61	0.48	2.58	0.098	6.2	0.57
114	1	2	1	3	89	22	228	8.2	2.9	2.0	0.76	0.38	2.48	0.075	6.4	0.48
115	1	2	1	3	89	23	315	8.5	2.4	2.2	0.89	0.45	3.65	0.120	7.7	0.78
116	1	2	1	3	89	24	409	8.2	3.8	1.9	0.95	0.34	3.18	0.090	4.3	0.50
117	1	2	1	3	89	25	415	8.8	4.0	2.2	0.92	0.94	2.38	0.136	4.9	0.42
118	1	2	1	3	89	26	480	7.8	3.8	1.9	0.83	0.26	2.71	0.105	7.3	0.50
119	1	2	1	3	89	27	548	8.4	3.9	2.3	0.76	0.66	1.22	0.128	5.6	0.57
120	1	2	1	3	89	28	632	8.0	4.6	1.9	1.20	0.73	3.00	0.073	3.2	0.30
121	1	2	1	3	89	29	798	7.9	4.0	1.6	1.18	0.65	2.29	0.079	5.1	0.43
122	1	2	1	3	89	30	904	8.6	3.0	2.3	1.21	0.59	2.16	0.113	7.3	0.54
123	1	2	1	3	89	31	953	8.7	3.1	1.9	1.07	0.66	2.48	0.098	6.8	0.50
124	1	2	2	3	89	32	36	9.2	2.9	2.4	1.19	0.64	2.43	0.075	8.7	0.63
125	1	2	2	3	89	33	103	7.7	3.3	2.3	0.77	0.59	2.43	0.068	6.4	0.54
126	1	2	2	3	89	34	256	8.6	3.1	2.1	0.74	0.55	1.68	0.098	5.4	0.55
127	1	2	2	3	89	35	293	8.1	2.0	2.3	0.47	0.45	2.18	0.090	4.5	0.48
128	1	2	2	3	89	36	369	8.9	3.1	1.7	0.89	0.52	2.73	0.068	5.1	0.76
129	1	2	2	3	89	37	387	7.8	4.5	2.0	1.01	0.79	1.94	0.051	3.9	0.31
130	1	2	2	3	89	38	411	8.4	2.3	2.2	0.99	0.51	2.83	0.120	5.5	0.62
131	1	2	2	3	89	39	510	8.7	4.6	2.0	0.96	1.04	2.23	0.056	5.0	0.16
132	1	2	2	3	89	40	544	8.9	2.6	2.1	0.90	0.63	1.52	0.143	6.4	0.45
133	1	2	2	3	89	41	901	8.7	2.3	2.4	1.00	0.64	1.95	0.120	6.3	0.40

134	2	1	1	3	89	42	85	7.6	4.0	2.1	0.63	0.67	2.03	0.090	4.8	0.96
135	2	1	1	3	89	43	261	8.0	3.3	1.9	1.03	0.79	3.47	0.113	4.6	0.90
136	2	1	1	3	89	44	266	7.8	4.6	2.1	0.92	0.68	4.05	.	8.1	0.74
137	2	1	1	3	89	45	268	7.5	5.1	2.1	1.05	0.71	3.61	0.079	8.4	0.31
138	2	1	1	3	89	46	291	8.5	3.6	2.3	0.97	0.65	2.75	0.080	6.6	0.79
139	2	1	1	3	89	47	307	8.9	3.9	2.3	1.09	0.63	2.43	0.119	6.7	0.90
140	2	1	1	3	89	48	482	7.9	4.3	2.3	0.97	0.52	1.89	0.102	7.6	0.86
141	2	1	1	3	89	49	502	8.4	4.4	2.3	1.01	0.66	2.75	0.113	3.4	0.40
142	2	1	1	3	89	50	504	8.5	4.3	2.4	0.86	0.73	3.09	0.107	4.9	0.66
143	2	1	1	3	89	51	516	7.0	5.1	2.4	0.95	0.47	2.29	0.136	4.5	0.99
144	2	1	1	3	89	52	856	6.7	4.3	1.9	1.15	0.62	3.09	0.113	5.9	0.82
145	2	1	2	3	89	53	25	7.7	4.3	2.0	0.82	0.75	3.34	0.090	6.7	0.81
146	2	1	2	3	89	54	262	8.1	4.4	2.1	1.07	0.69	4.42	0.096	6.8	0.55
147	2	1	2	3	89	55	280	7.2	3.5	2.1	0.80	0.54	1.70	0.085	6.1	0.61
148	2	1	2	3	89	56	297	7.8	4.5	1.8	0.89	1.85	1.90	0.113	4.5	1.04
149	2	1	2	3	89	57	318	8.4	4.1	2.1	0.74	0.83	2.34	0.090	5.3	0.47
150	2	1	2	3	89	58	875	7.7	3.6	2.3	1.02	0.69	3.41	0.090	8.0	0.83
151	2	1	2	3	89	59	882	8.3	3.5	2.5	0.95	0.86	3.01	0.073	6.6	0.59
152	2	1	2	3	89	60	891	8.7	3.9	2.2	1.12	0.64	2.45	0.102	8.5	0.65
153	2	2	1	3	89	61	288	8.7	3.8	2.3	0.86	0.40	2.83	0.090	6.9	0.45
154	2	2	1	3	89	62	310	8.7	2.8	2.5	0.78	0.48	2.57	0.135	4.8	0.44
155	2	2	1	3	89	63	323	8.1	2.9	1.8	0.76	0.42	2.90	0.104	7.1	0.61
156	2	2	1	3	89	64	336	8.2	3.1	1.8	0.95	0.54	2.99	0.105	4.7	0.68
157	2	2	1	3	89	65	355	7.9	2.6	2.1	0.68	0.44	3.05	0.051	6.0	0.70
158	2	2	1	3	89	66	522	8.5	2.8	2.2	0.79	0.65	2.34	0.030	6.8	0.53
159	2	2	1	3	89	67	550	8.3	2.3	2.3	0.83	0.62	1.96	0.045	5.7	0.65
160	2	2	1	3	89	68	897	8.8	2.6	2.4	0.75	0.90	1.99	0.083	8.2	0.55
161	2	2	1	3	89	69	954	9.5	3.5	2.4	0.95	0.67	2.52	0.113	7.0	0.43
162	2	2	1	3	89	70	965	8.2	2.9	2.2	1.18	0.44	1.81	0.075	8.5	0.34
163	2	2	2	3	89	71	122	8.2	2.4	2.1	1.21	0.63	2.24	0.090	5.8	0.78
164	2	2	2	3	89	72	124	7.9	2.6	2.0	0.87	0.46	2.35	0.105	5.1	0.69
165	2	2	2	3	89	73	125	8.3	2.7	1.9	1.02	0.46	2.26	0.113	6.0	0.42
166	2	2	2	3	89	74	251	8.1	3.1	2.0	0.61	0.67	1.35	0.120	4.6	0.48
167	2	2	2	3	89	75	332	7.8	2.0	1.9	0.64	0.43	2.49	0.090	5.8	0.37
168	2	2	2	3	89	76	371	7.7	3.7	1.8	0.77	0.38	2.65	0.158	5.8	0.42
169	2	2	2	3	89	77	385	8.6	2.7	2.1	0.92	0.37	3.73	0.060	5.5	0.35
170	2	2	2	3	89	78	744	8.4	3.3	1.9	0.71	0.55	1.17	0.060	7.2	0.48
171	2	2	2	3	89	79	908	8.6	2.2	2.3	1.08	0.49	2.44	0.075	9.1	0.49
172	2	2	2	3	89	80	912	8.9	3.4	2.4	1.03	0.56	2.02	0.090	5.9	0.50
173	2	2	2	3	89	81	937	8.4	3.3	2.2	0.95	0.51	1.56	0.090	6.9	0.51
174	1	1	1	6	89	1	53	7.6	3.3	2.1	0.50	0.80	2.68	0.094	5.0	0.74
175	1	1	1	6	89	2	82	7.8	3.3	2.1	0.65	0.90	2.51	0.094	7.6	2.08
176	1	1	1	6	89	3	105	8.6	3.1	1.8	0.51	0.72	2.12	0.101	4.5	1.20
177	1	1	1	6	89	4	139	8.4	4.0	1.3	0.75	0.84	2.50	0.101	5.9	2.03
178	1	1	1	6	89	5	141	8.5	2.6	1.7	0.59	0.67	2.23	0.109	3.7	1.19
179	1	1	1	6	89	6	155	8.6	3.5	1.9	0.48	0.79	2.51	0.094	7.3	1.97
180	1	1	1	6	89	7	207	8.3	2.4	1.4	0.87	0.86	3.00	0.087	5.9	2.39
181	1	1	1	6	89	8	210	8.6	3.9	1.5	0.86	0.74	2.51	0.072	3.4	0.75
182	1	1	1	6	89	9	273	8.0	3.1	1.5	0.56	0.84	2.57	0.130	5.1	0.71
183	1	1	1	6	89	10	699	8.0	3.1	1.6	0.89	0.68	2.54	0.094	6.8	0.75
184	1	1	2	6	89	11	50	8.8	3.0	2.2	0.73	0.88	2.22	0.049	4.4	1.22
185	1	1	2	6	89	12	78	8.6	3.4	1.9	0.57	0.66	2.13	0.109	6.6	1.80
186	1	1	2	6	89	13	101	8.8	3.6	1.6	0.97	0.68	2.34	0.109	5.5	1.04
187	1	1	2	6	89	14	189	8.1	4.4	1.6	0.73	0.55	2.16	0.087	4.3	1.22
188	1	1	2	6	89	15	212	9.4	4.3	1.1	0.71	0.86	2.02	0.123	4.2	0.96
189	1	1	2	6	89	16	222	8.6	3.8	1.5	0.66	0.70	2.39	0.065	4.0	1.35
190	1	1	2	6	89	17	301	7.8	2.4	1.7	0.64	0.60	2.53	0.080	3.8	1.33
191	1	1	2	6	89	18	378	7.5	2.4	2.3	0.51	0.81	3.04	0.072	6.9	.
192	1	1	2	6	89	19	527	8.2	3.6	1.7	0.68	0.76	2.54	0.087	4.8	0.66
193	1	2	1	6	89	20	151	8.4	4.0	1.9	0.57	0.89	3.07	0.086	7.7	0.32
194	1	2	1	6	89	21	228	8.3	3.5	2.1	0.80	0.87	2.90	0.117	10.2	2.34
195	1	2	1	6	89	22	315	8.7	3.5	1.8	0.92	0.88	2.53	0.086	11.4	0.76
196	1	2	1	6	89	23	409	7.4	3.3	2.1	0.69	0.60	2.29	0.086	4.7	1.02
197	1	2	1	6	89	24	415	8.9	3.6	2.0	1.03	1.03	2.53	0.074	5.6	0.95
198	1	2	1	6	89	25	480	7.9	4.5	1.8	0.87	0.66	2.43	0.061	6.4	0.85
199	1	2	1	6	89	26	548	7.2	4.4	2.0	0.88	1.06	2.56	0.092	5.9	1.05
200	1	2	1	6	89	27	632	7.7	3.3	1.9	0.99	0.70	2.28	0.049	7.4	1.35
201	1	2	1	6	89	28	798	7.4	3.8	1.6	0.82	0.88	2.41	0.067	10.7	0.61
202	1	2	1	6	89	29	904	8.5	3.9	2.2	1.05	0.84	2.53	0.074	7.9	0.78

203	1	2	1	6	89	30	953	8.4	4.0	1.4	0.95	0.93	2.42	0.049	7.4	0.63
204	1	2	2	6	89	31	36	8.3	3.4	2.3	0.83	0.94	2.39	0.037	.	0.61
205	1	2	2	6	89	32	103	8.5	3.6	2.0	0.74	0.88	2.68	0.031	9.6	0.89
206	1	2	2	6	89	33	256	7.8	3.0	2.1	0.82	1.01	2.84	0.080	6.9	0.47
207	1	2	2	6	89	34	293	7.9	3.1	2.1	0.62	0.95	2.44	0.099	6.2	1.39
208	1	2	2	6	89	35	369	7.9	3.9	1.8	0.91	1.06	2.79	0.067	6.6	1.19
209	1	2	2	6	89	36	387	8.5	3.9	2.2	0.75	1.00	2.56	0.031	9.2	0.76
210	1	2	2	6	89	37	411	8.2	4.1	2.1	0.94	0.74	2.33	0.049	5.4	0.47
211	1	2	2	6	89	38	510	8.9	3.6	2.4	0.72	1.14	2.52	0.080	9.8	0.42
212	1	2	2	6	89	39	544	7.9	2.8	2.0	0.83	0.95	2.78	0.147	8.1	1.01
213	1	2	2	6	89	40	901	8.1	4.4	2.0	0.70	0.89	2.06	0.055	7.5	0.38
214	2	1	1	6	89	41	85	7.6	4.0	1.9	0.50	0.59	2.37	0.128	5.6	1.03
215	2	1	1	6	89	42	261	9.6	4.0	1.8	0.48	1.13	2.77	0.165	4.7	0.74
216	2	1	1	6	89	43	266	8.6	5.0	2.0	0.76	1.36	2.88	0.098	11.3	0.81
217	2	1	1	6	89	44	268	6.0	3.0	1.9	0.50	0.87	2.49	0.120	7.4	0.62
218	2	1	1	6	89	45	291	8.9	3.5	2.3	0.55	0.73	2.90	0.092	7.2	.
219	2	1	1	6	89	46	307	7.8	3.6	2.0	0.67	0.78	2.15	0.067	8.7	0.83
220	2	1	1	6	89	47	482	7.0	2.0	2.0	0.82	0.79	3.14	0.092	10.2	0.96
221	2	1	1	6	89	48	502	8.7	3.9	1.8	0.75	0.93	2.48	0.086	7.1	0.84
222	2	1	1	6	89	49	504	8.4	3.1	2.0	0.67	1.03	2.45	0.098	8.4	0.86
223	2	1	1	6	89	50	516	7.8	4.9	2.0	0.68	0.71	2.57	0.123	7.3	1.03
224	2	1	1	6	89	51	856	6.8	2.9	1.8	0.79	1.05	2.77	0.086	5.1	0.63
225	2	1	2	6	89	52	25	8.7	3.8	1.9	0.51	0.90	2.30	0.173	7.7	0.84
226	2	1	2	6	89	53	262	7.8	3.8	1.8	0.54	0.87	2.32	0.101	7.9	1.04
227	2	1	2	6	89	54	280	8.4	4.3	2.0	0.59	0.93	2.46	0.074	7.3	.
228	2	1	2	6	89	55	297	8.4	4.1	1.7	0.51	1.06	2.49	0.110	7.9	2.07
229	2	1	2	6	89	56	318	7.9	3.3	1.8	0.66	0.87	2.57	0.098	8.0	0.85
230	2	1	2	6	89	57	875	8.2	4.5	1.9	0.82	1.12	3.45	0.061	13.9	0.71
231	2	1	2	6	89	58	882	8.8	3.5	2.0	0.70	1.03	2.58	0.043	9.4	0.52
232	2	1	2	6	89	59	891	8.8	3.4	1.9	0.90	0.77	2.21	0.086	9.1	0.89
233	2	2	1	6	89	60	288	7.5	2.5	2.0	0.92	0.70	2.40	0.067	8.9	0.86
234	2	2	1	6	89	61	310	9.0	3.9	2.1	0.96	1.12	1.89	0.061	7.4	1.03
235	2	2	1	6	89	62	323	8.4	2.3	1.7	0.51	0.95	2.14	0.101	8.9	1.03
236	2	2	1	6	89	63	336	7.6	1.8	1.5	0.80	0.82	2.17	0.049	5.4	0.77
237	2	2	1	6	89	64	355	8.6	2.8	2.1	0.79	0.90	2.66	0.043	6.3	0.79
238	2	2	1	6	89	65	522	6.9	2.1	1.8	1.22	0.96	4.08	0.074	6.8	0.81
239	2	2	1	6	89	66	550	6.4	2.8	2.1	1.17	1.17	3.94	0.074	6.6	2.42
240	2	2	1	6	89	67	897	7.3	2.9	1.6	1.23	1.53	3.85	0.104	14.6	1.72
241	2	2	1	6	89	68	954	8.5	2.4	2.1	0.97	0.79	2.35	0.067	7.5	0.78
242	2	2	1	6	89	69	965	8.3	3.3	1.7	0.69	0.83	1.78	0.067	8.5	0.90
243	2	2	2	6	89	70	122	7.2	1.0	1.6	0.78	0.79	2.57	0.098	11.5	0.77
244	2	2	2	6	89	71	124	6.8	1.8	1.8	0.93	0.63	2.16	0.061	7.5	2.40
245	2	2	2	6	89	72	125	8.0	2.6	1.6	0.83	0.82	1.99	0.061	9.5	0.62
246	2	2	2	6	89	73	251	9.2	5.9	1.7	0.59	1.43	2.38	0.043	2.5	0.81
247	2	2	2	6	89	74	332	8.5	2.8	1.7	0.76	0.67	2.38	0.025	9.0	0.45
248	2	2	2	6	89	75	371	7.1	2.9	1.6	0.56	0.81	1.67	0.037	10.1	0.97
249	2	2	2	6	89	76	385	6.2	2.0	2.0	1.29	0.98	4.36	0.147	8.5	0.84
250	2	2	2	6	89	77	744	6.6	3.0	1.5	1.19	0.96	3.58	0.067	5.7	2.74
251	2	2	2	6	89	78	908	6.8	1.5	2.1	1.45	0.81	3.81	0.043	9.5	0.89
252	2	2	2	6	89	79	912	6.6	2.4	2.5	1.14	0.86	4.18	0.037	7.5	0.90
253	2	2	2	6	89	80	937	8.6	2.9	1.8	1.03	0.75	2.48	0.031	5.2	0.69
254	1	1	1	10	89	1	53	10.0	4.6	1.9	0.89	0.55	1.17	0.071	7.5	0.78
255	1	1	1	10	89	2	82	10.9	2.7	2.2	0.96	0.57	0.82	0.071	6.4	0.78
256	1	1	1	10	89	3	105	8.7	4.0	1.7	0.68	0.44	0.69	0.060	5.8	1.03
257	1	1	1	10	89	4	139	10.9	2.8	2.0	0.99	0.42	0.89	0.099	6.7	1.12
258	1	1	1	10	89	5	141	11.4	3.5	1.7	0.93	0.54	0.88	0.110	8.0	1.42
259	1	1	1	10	89	6	155	9.5	2.8	1.5	0.92	0.37	0.57	0.077	6.7	0.64
260	1	1	1	10	89	7	207	8.7	1.5	1.4	1.06	0.33	1.20	0.066	6.3	1.62
261	1	1	1	10	89	8	210	12.7	4.8	1.8	1.02	0.57	0.82	0.077	5.9	0.74
262	1	1	1	10	89	9	273	12.3	3.8	1.7	1.33	0.51	0.52	0.115	5.9	0.77
263	1	1	1	10	89	10	699	12.3	2.3	1.6	1.20	0.65	0.67	0.104	6.9	1.03
264	1	1	2	10	89	11	50	13.2	6.1	2.2	1.04	0.79	1.13	0.093	11.5	0.88
265	1	1	2	10	89	12	78	10.4	3.4	1.9	1.05	0.51	1.13	0.099	6.6	.
266	1	1	2	10	89	13	101	12.0	3.5	1.8	1.21	0.70	0.96	0.066	7.8	0.49
267	1	1	2	10	89	14	189	11.7	3.8	1.6	1.02	0.27	1.12	0.154	6.1	0.97
268	1	1	2	10	89	15	212	12.0	2.7	1.7	1.15	0.59	0.52	0.071	6.8	1.50
269	1	1	2	10	89	16	222	11.7	3.2	2.0	1.07	0.52	1.00	0.082	7.8	0.74
270	1	1	2	10	89	17	301	12.0	4.2	2.0	1.05	0.55	0.77	0.060	5.3	0.91
271	1	1	2	10	89	18	378	11.0	2.2	2.2	0.93	0.61	0.77	0.066	11.3	0.78

272	1	1	2	10	89	19	527	12.3	3.0	1.7	1.34	0.57	1.55	0.060	4.2	0.60
273	1	2	1	10	89	20	151	12.5	3.8	2.0	0.80	0.54	2.67	0.038	6.9	0.75
274	1	2	1	10	89	21	228	12.5	3.7	2.0	0.83	0.52	1.53	0.060	6.7	1.04
275	1	2	1	10	89	22	315	12.0	3.7	1.7	0.79	0.73	1.95	0.055	11.0	0.82
276	1	2	1	10	89	23	409	12.1	5.4	1.8	0.91	0.54	1.89	0.038	9.1	0.52
277	1	2	1	10	89	24	415	13.6	2.2	2.2	1.06	0.77	2.04	0.077	7.5	0.78
278	1	2	1	10	89	25	480	11.8	5.3	1.6	1.01	0.39	1.81	0.115	7.9	1.14
279	1	2	1	10	89	26	548	12.2	3.2	2.0	1.13	0.84	2.04	0.055	9.3	0.87
280	1	2	1	10	89	27	632	12.3	3.4	1.9	1.03	0.55	2.13	0.033	5.2	0.72
281	1	2	1	10	89	28	798	11.6	3.0	1.6	1.04	0.60	1.87	0.066	7.7	1.06
282	1	2	1	10	89	29	904	12.1	4.1	2.0	1.13	0.48	2.19	0.093	9.0	0.83
283	1	2	1	10	89	30	953	12.4	3.7	1.9	1.32	0.73	2.24	0.049	10.6	0.86
284	1	2	2	10	89	31	36	11.8	2.7	2.0	1.00	0.60	0.32	0.071	8.9	0.82
285	1	2	2	10	89	32	103	13.0	4.2	1.8	1.01	0.64	0.52	0.038	8.8	0.64
286	1	2	2	10	89	33	256	12.8	4.3	2.0	1.02	0.68	1.73	0.071	6.7	1.30
287	1	2	2	10	89	34	293	12.9	3.5	1.9	0.79	0.83	1.93	0.066	6.2	0.65
288	1	2	2	10	89	35	369	13.3	3.8	1.9	0.93	0.77	2.81	0.126	8.9	1.44
289	1	2	2	10	89	36	387	13.2	3.7	1.9	1.02	0.81	1.89	0.033	9.7	0.78
290	1	2	2	10	89	37	411	13.0	2.7	1.9	1.07	0.44	2.01	0.060	7.0	1.54
291	1	2	2	10	89	38	510	13.2	4.9	2.0	0.90	0.71	2.08	0.033	7.0	0.75
292	1	2	2	10	89	39	544	12.3	2.5	1.8	1.00	0.70	1.77	0.033	7.3	0.60
293	1	2	2	10	89	40	901	11.1	3.6	1.8	0.94	0.48	1.56	0.038	7.5	0.70
294	2	1	1	10	89	41	85	12.0	5.1	2.0	0.91	0.48	2.24	0.077	4.8	0.61
295	2	1	1	10	89	42	261	.	.	.	.	.	.	0.049	.	.
296	2	1	1	10	89	43	266	12.8	6.4	1.9	1.13	0.54	2.12	0.044	9.5	0.68
297	2	1	1	10	89	44	268	12.0	5.0	2.1	1.04	0.47	1.83	0.093	9.4	1.56
298	2	1	1	10	89	45	291	13.1	4.9	2.6	1.11	0.41	1.83	.	10.5	0.73
299	2	1	1	10	89	46	307	13.0	4.1	2.0	1.10	0.43	1.13	0.099	8.0	0.76
300	2	1	1	10	89	47	482	12.8	3.4	2.1	1.21	0.31	1.91	0.049	8.7	0.91
301	2	1	1	10	89	48	502	12.7	5.2	2.1	1.27	0.54	1.68	0.038	7.0	0.87
302	2	1	1	10	89	49	504	13.5	4.4	2.5	1.11	0.44	2.16	0.033	8.5	0.82
303	2	1	1	10	89	50	516	11.6	5.5	2.4	1.11	0.35	1.46	0.066	7.5	0.92
304	2	1	1	10	89	51	856	10.0	4.7	2.1	1.13	0.39	1.28	0.044	8.3	0.92
305	2	1	2	10	89	52	25	12.8	4.5	2.0	1.05	0.58	1.99	0.027	8.9	1.04
306	2	1	2	10	89	53	262	12.5	4.6	1.9	1.36	0.38	1.83	0.033	5.9	1.67
307	2	1	2	10	89	54	280	12.5	3.8	2.3	1.14	0.48	1.95	0.060	6.4	0.72
308	2	1	2	10	89	55	297	11.7	6.2	2.2	0.99	0.47	1.64	0.082	5.9	1.23
309	2	1	2	10	89	56	318	12.5	4.5	1.9	1.25	0.50	1.79	0.038	8.6	0.92
310	2	1	2	10	89	57	875	12.1	3.7	2.4	1.50	0.36	1.62	0.027	12.0	0.59
311	2	1	2	10	89	58	882	12.9	3.5	2.4	1.02	0.36	1.42	0.051	9.4	0.74
312	2	1	2	10	89	59	891	13.7	3.7	1.8	1.31	0.26	1.53	0.095	10.8	0.80
313	2	2	1	10	89	60	288	13.2	1.9	2.1	1.32	0.58	1.81	0.038	7.7	0.59
314	2	2	1	10	89	61	310	13.3	3.6	2.2	1.31	0.52	1.71	0.032	6.1	1.29
315	2	2	1	10	89	62	323	12.8	2.9	1.8	1.10	0.55	1.99	0.032	6.9	0.60
316	2	2	1	10	89	63	336	12.9	3.1	1.6	1.12	0.58	2.26	0.082	4.7	0.61
317	2	2	1	10	89	64	355	13.3	3.3	1.9	1.11	0.41	2.18	0.032	7.6	0.83
318	2	2	1	10	89	65	522	11.5	3.1	1.8	1.11	0.42	2.30	0.025	5.6	0.82
319	2	2	1	10	89	66	550	12.3	2.7	2.2	1.23	0.50	2.71	0.032	7.6	0.74
320	2	2	1	10	89	67	897	13.2	2.9	2.0	1.34	0.77	2.29	0.025	11.2	0.61
321	2	2	1	10	89	68	954	14.1	2.2	2.1	1.18	0.54	2.79	0.057	9.3	0.57
322	2	2	1	10	89	69	965	13.3	3.3	2.0	1.23	0.48	2.14	0.025	9.5	0.51
323	2	2	2	10	89	70	122	12.6	3.0	2.0	1.18	0.72	1.13	0.032	5.7	0.76
324	2	2	2	10	89	71	124	13.0	3.7	1.9	1.17	0.27	1.16	0.095	5.9	0.52
325	2	2	2	10	89	72	125	12.1	2.7	1.8	1.39	0.53	0.91	0.057	8.9	0.51
326	2	2	2	10	89	73	251	12.1	3.4	1.7	1.10	0.72	2.46	0.032	3.7	0.58
327	2	2	2	10	89	74	332	12.3	2.4	1.6	1.35	0.41	1.73	0.044	4.9	0.49
328	2	2	2	10	89	75	371	11.8	4.4	1.7	1.08	0.37	1.74	0.025	7.0	0.50
329	2	2	2	10	89	76	385	12.7	3.0	2.0	1.21	0.64	2.18	0.063	8.9	0.47
330	2	2	2	10	89	77	744	12.5	4.1	1.4	1.15	0.50	1.69	0.006	5.3	1.37
331	2	2	2	10	89	78	908	13.9	4.2	2.0	1.41	0.53	2.26	0.063	10.3	0.69
332	2	2	2	10	89	79	912	13.5	3.1	2.0	1.43	0.47	2.48	0.032	8.2	0.68
333	2	2	2	10	89	80	937	13.2	4.7	2.1	1.11	0.76	2.53	0.063	6.6	0.65

SERUM CALVES DATA CODES
(Experiments 1 and 2)

OB = Observation number (1-209).

LO = Location: 1. Bronson.
2. Williston.

Se = Selenium: 1. Treated.
2. Control.

VE = Vitamin E: 1. Treated.
2. Control.

YR = Year (88 and 89).

MT = Month: 6. June.
10. October.

OS = Sample observation number.

CLF = Calf number.

Ca = Calcium, mg/dl.

P = Phosphorus, mg/dl.

Mg = Magnesium, mg/dl.

Cu = Copper, ppm.

Zn = Zinc, ppm.

Fe = Iron, ppm.

Sel = Selenium, ppm.

SERUM CALVES DATA

OB	LO	Se	VE	YR	MT	OS	CLF	Ca	P	Mg	Cu	Zn	Fe	Sel	Vit
1	1	1	.	88	6	1	207	13.6	12.4	2.6	1.04	1.70	3.5	0.023	.
2	1	1	.	88	6	2	208	4.8	7.1	1.4	0.42	0.85	0.4	0.031	.
3	1	1	.	88	6	3	215	6.8	9.7	2.1	0.68	1.11	0.6	0.029	.
4	1	1	.	88	6	4	216	6.2	8.5	1.6	0.78	1.04	0.6	0.079	.
5	1	1	.	88	6	5	217	6.9	8.9	2.1	0.54	1.11	1.7	0.014	.
6	1	1	.	88	6	6	218	8.9	8.9	2.1	0.97	1.32	2.3	0.026	.
7	1	1	.	88	6	7	219	7.2	8.0	1.4	0.45	0.87	1.2	0.016	.
8	1	1	.	88	6	8	220	10.3	11.7	3.0	1.11	1.26	2.6	0.016	.
9	1	1	.	88	6	9	221	9.0	10.6	1.7	0.96	1.02	1.2	0.040	.
10	1	1	.	88	6	10	222	8.7	9.4	2.1	0.92	0.87	1.4	0.026	.
11	1	1	.	88	6	11	223	6.2	7.8	1.9	0.73	0.72	1.0	0.034	.
12	1	1	.	88	6	12	224	6.1	7.4	1.9	1.04	0.85	2.1	0.026	.
13	1	2	.	88	6	13	227	15.2	10.9	2.6	1.41	1.52	2.7	0.045	.
14	1	2	.	88	6	14	230	11.0	11.8	2.3	0.62	1.44	1.9	0.048	.
15	1	2	.	88	6	15	231	11.4	10.6	2.1	0.30	1.68	3.4	0.028	.
16	1	2	.	88	6	16	234	11.3	11.3	2.2	1.38	1.97	2.3	0.018	.
17	1	2	.	88	6	17	236	9.5	10.3	2.0	0.63	0.93	1.3	0.075	.
18	1	2	.	88	6	18	239	7.1	8.7	1.7	1.00	1.28	0.9	0.125	.
19	1	2	.	88	6	19	240	12.2	10.8	2.4	0.57	1.13	1.5	0.035	.
20	1	2	.	88	6	20	241	6.4	8.0	1.6	0.21	0.97	1.0	0.031	.
21	1	2	.	88	6	21	246	11.3	10.3	2.2	1.15	1.28	1.8	0.026	.
22	1	2	.	88	6	22	248	9.9	11.3	2.6	1.11	1.50	1.2	0.040	.
23	1	2	.	88	6	23	249	7.7	8.4	1.9	0.61	1.13	1.9	0.033	.
24	2	1	.	88	6	24	440	9.2	9.4	2.2	0.48	1.21	1.7	0.026	.
25	2	1	.	88	6	25	444	7.4	7.7	1.7	1.16	0.72	1.5	0.015	.
26	2	1	.	88	6	26	445	8.1	8.2	1.9	0.48	0.88	1.4	0.024	.
27	2	1	.	88	6	27	446	8.3	8.3	1.7	0.67	0.96	1.1	0.022	.
28	2	1	.	88	6	28	447	9.4	9.0	2.1	0.89	1.19	2.4	0.017	.
29	2	1	.	88	6	29	448	7.4	8.7	1.1	0.45	1.15	1.4	0.023	.
30	2	1	.	88	6	30	449	7.5	7.3	1.3	0.44	0.84	0.7	0.046	.
31	2	1	.	88	6	31	497	8.6	9.1	1.8	0.37	1.19	0.9	0.029	.
32	2	1	.	88	6	32	498	7.8	6.3	2.4	0.21	0.82	1.2	0.035	.
33	2	1	.	88	6	33	499	7.3	8.1	1.9	0.39	0.84	0.7	0.012	.
34	2	1	.	88	6	34	500	6.8	7.9	2.3	0.31	0.84	0.6	.	.
35	2	2	.	88	6	35	226	12.2	12.4	2.9	1.57	1.18	0.5	0.021	.
36	2	2	.	88	6	36	229	7.4	8.7	1.7	1.10	0.82	1.6	0.022	.
37	2	2	.	88	6	37	233	6.3	7.9	1.4	0.64	0.97	.	0.013	.
38	2	2	.	88	6	38	235	5.7	7.5	1.3	0.44	0.85	0.3	0.020	.
39	2	2	.	88	6	39	237	10.0	9.3	1.9	0.77	1.01	0.3	0.015	.
40	2	2	.	88	6	40	238	7.2	7.7	1.5	0.59	1.11	0.5	0.016	.
41	2	2	.	88	6	41	243	5.6	8.1	1.4	0.39	0.56	0.2	0.016	.
42	2	2	.	88	6	42	244	8.4	8.7	1.9	0.65	0.92	0.1	0.018	.
43	2	2	.	88	6	43	245	6.7	7.9	1.7	1.27	1.05	0.7	0.035	.
44	2	2	.	88	6	44	247	7.8	8.8	2.0	0.56	0.62	0.8	0.019	.
45	1	1	.	88	10	1	208	9.7	6.1	2.1	0.52	0.94	0.3	0.014	.
46	1	1	.	88	10	2	216	10.8	5.3	2.1	0.53	1.08	0.4	0.063	.
47	1	1	.	88	10	3	217	9.8	6.2	2.2	0.54	1.02	2.2	0.035	.
48	1	1	.	88	10	4	218	11.2	6.7	2.1	0.75	1.10	1.8	0.063	.
49	1	1	.	88	10	5	220	11.0	7.4	2.3	0.75	1.37	2.1	0.056	.
50	1	1	.	88	10	6	221	11.3	7.4	2.0	0.87	1.00	0.2	0.070	.
51	1	1	.	88	10	7	222	11.5	6.5	2.0	0.61	1.16	0.7	0.063	.
52	1	1	.	88	10	8	223	10.6	6.8	2.2	0.66	1.07	1.1	0.077	.
53	1	1	.	88	10	9	224	10.1	7.1	2.0	0.78	0.85	0.3	0.035	.
54	1	2	.	88	10	10	227	10.1	5.8	2.2	0.79	1.01	0.2	0.056	.
55	1	2	.	88	10	11	230	8.5	5.8	1.9	0.48	0.91	0.2	0.035	.
56	1	2	.	88	10	12	231	9.0	6.6	2.1	0.39	0.96	0.5	0.042	.
57	1	2	.	88	10	13	234	10.0	6.8	2.2	0.61	1.01	0.4	0.042	.
58	1	2	.	88	10	14	236	9.9	6.8	2.0	0.65	1.08	0.7	0.035	.
59	1	2	.	88	10	15	239	10.8	7.4	2.0	1.02	1.36	0.2	0.042	.
60	1	2	.	88	10	16	240	10.7	5.3	2.0	0.74	1.04	1.1	0.049	.
61	1	2	.	88	10	17	241	10.0	6.8	2.1	0.57	1.21	1.2	.	.
62	1	2	.	88	10	18	246	10.4	5.9	2.1	0.61	1.08	0.6	0.042	.
63	1	2	.	88	10	19	248	9.9	7.0	2.3	0.66	1.01	1.2	0.035	.
64	1	2	.	88	10	20	249	9.7	6.5	2.0	0.39	0.92	1.3	0.028	.

65	2	1	.	88	10	21	440	10.1	6.3	2.3	0.62	0.89	0.8	0.092	.
66	2	1	.	88	10	22	444	10.6	6.5	2.0	0.75	0.82	1.2	0.085	.
67	2	1	.	88	10	23	445	11.0	4.6	2.2	0.69	0.89	0.5	0.028	.
68	2	1	.	88	10	24	448	9.8	6.7	2.1	0.55	0.89	1.1	0.070	.
69	2	1	.	88	10	25	497	6.9	3.2	1.4	0.33	0.79	0.5	.	.
70	2	1	.	88	10	26	498	8.9	6.1	2.0	0.45	0.91	1.6	0.113	.
71	2	1	.	88	10	27	499	9.6	6.8	2.0	0.58	1.13	2.4	0.085	.
72	2	1	.	88	10	28	500	9.8	3.8	2.0	0.27	1.01	0.6	0.141	.
73	2	2	.	88	10	29	228	9.7	6.3	2.1	0.57	1.30	2.2	0.099	.
74	2	2	.	88	10	30	229	10.2	6.2	2.2	0.71	0.91	1.3	0.045	.
75	2	2	.	88	10	31	232	9.8	5.4	2.2	0.67	0.60	1.2	0.051	.
76	2	2	.	88	10	32	233	10.3	5.9	2.5	0.96	1.01	1.2	0.023	.
77	2	2	.	88	10	33	235	10.0	4.6	2.2	0.63	1.27	1.1	0.079	.
78	2	2	.	88	10	34	237	9.6	4.5	2.2	0.39	0.72	0.1	0.034	.
79	2	2	.	88	10	35	238	8.9	5.7	1.9	0.34	0.70	0.2	0.034	.
80	2	2	.	88	10	36	243	8.7	5.4	2.0	0.19	0.91	0.1	0.023	.
81	2	2	.	88	10	37	244	8.9	5.9	2.0	0.31	1.17	0.1	0.023	.
82	2	2	.	88	10	38	245	9.5	7.2	2.3	0.48	1.37	0.5	0.028	.
83	2	2	.	88	10	39	247	9.4	6.6	2.1	0.95	0.99	0.4	0.040	.
84	1	1	1	89	6	1	271	11.0	7.3	1.9	0.18	1.67	1.3	0.060	1.0
85	1	1	1	89	6	2	273	10.3	5.9	2.0	0.33	0.67	0.1	0.033	.
86	1	1	1	89	6	3	274	10.4	6.3	1.9	0.37	1.16	2.1	0.046	2.6
87	1	1	1	89	6	4	279	11.4	6.3	1.8	0.45	1.23	1.9	.	.
88	1	1	1	89	6	5	282	11.2	7.1	2.1	0.23	1.17	2.7	0.099	2.6
89	1	1	1	89	6	6	289	11.6	8.0	2.2	0.24	0.99	1.9	0.013	2.7
90	1	1	2	89	6	7	269	10.2	7.9	1.9	0.39	1.45	2.6	.	1.6
91	1	1	2	89	6	8	272	11.1	6.3	1.8	0.11	1.31	4.1	0.033	3.1
92	1	1	2	89	6	9	278	10.9	7.4	2.1	0.21	0.81	2.2	0.086	1.7
93	1	1	2	89	6	10	280	11.1	7.1	1.9	0.18	1.15	1.3	0.119	.
94	1	1	2	89	6	11	283	11.1	7.8	2.2	0.30	1.04	2.7	0.013	2.4
95	1	2	1	89	6	12	290	11.2	7.5	2.0	0.24	1.28	1.1	0.020	1.7
96	1	2	1	89	6	13	293	12.0	7.5	1.8	0.24	1.75	1.6	0.026	2.4
97	1	2	1	89	6	14	296	11.9	6.9	1.7	0.23	1.29	1.9	0.020	2.7
98	1	2	1	89	6	15	300	12.1	7.0	2.1	0.52	1.63	2.8	0.106	.
99	1	2	1	89	6	16	301	12.3	7.1	2.2	0.34	1.32	1.7	0.020	2.3
100	1	2	1	89	6	17	302	11.7	7.3	1.8	0.48	1.44	2.6	0.020	3.7
101	1	2	1	89	6	18	303	12.7	6.6	1.8	0.32	1.27	2.4	.	7.1
102	1	2	1	89	6	19	304	12.0	7.0	1.9	0.30	1.55	0.7	0.026	7.7
103	1	2	1	89	6	20	306	11.8	7.8	1.9	0.41	1.59	1.5	0.066	2.3
104	1	2	1	89	6	21	307	11.3	7.0	1.6	0.63	1.45	1.5	0.013	0.8
105	1	2	1	89	6	22	308	12.0	8.1	1.9	0.43	1.84	0.7	0.079	1.1
106	1	2	2	89	6	23	291	12.8	7.6	2.3	0.42	1.65	1.3	0.026	2.5
107	1	2	2	89	6	24	292	11.9	7.4	1.9	0.23	1.55	0.9	0.026	2.1
108	1	2	2	89	6	25	294	11.5	7.1	1.7	0.30	1.55	1.3	0.040	2.4
109	1	2	2	89	6	26	295	12.0	7.3	1.9	0.18	1.49	2.2	.	1.1
110	1	2	2	89	6	27	297	12.7	6.8	1.8	0.19	1.42	0.7	0.033	3.2
111	1	2	2	89	6	28	298	12.2	7.3	2.0	0.20	1.41	1.0	0.020	3.3
112	1	2	2	89	6	29	299	11.8	6.9	2.0	0.56	1.55	1.6	0.079	4.4
113	1	2	2	89	6	30	305	12.4	7.6	2.1	0.37	1.33	2.3	0.060	.
114	2	1	1	89	6	31	227	7.3	4.3	2.0	0.29	1.04	4.4	0.051	1.6
115	2	1	1	89	6	32	230	8.1	6.8	1.9	0.49	1.35	4.2	0.094	0.5
116	2	1	1	89	6	33	228	7.5	6.7	2.0	0.55	1.28	3.2	0.051	1.9
117	2	1	1	89	6	34	232	7.1	5.9	1.5	0.26	1.07	2.7	0.051	1.3
118	2	1	1	89	6	35	234	7.9	7.1	2.0	0.56	1.28	4.5	0.051	1.6
119	2	1	1	89	6	36	240	7.8	6.0	2.0	0.86	1.20	2.9	0.051	3.0
120	2	1	1	89	6	37	241	7.9	7.1	2.2	0.87	1.10	4.1	0.058	.
121	2	1	1	89	6	38	242	7.5	6.2	2.2	0.69	1.09	3.1	0.065	1.5
122	2	1	1	89	6	39	243	7.4	6.6	1.9	0.69	0.73	3.2	0.065	2.2
123	2	1	2	89	6	40	231	7.0	5.6	1.7	0.60	0.97	3.4	0.036	2.1
124	2	1	2	89	6	41	235	7.6	7.1	1.9	0.80	1.16	3.1	0.029	0.7
125	2	1	2	89	6	42	236	7.7	6.6	2.1	0.67	1.02	3.2	0.014	0.3
126	2	1	2	89	6	43	238	7.4	6.6	1.5	0.66	1.05	3.6	0.080	2.8
127	2	1	2	89	6	44	239	7.3	6.8	2.0	0.50	1.08	3.3	0.058	0.3
128	2	1	2	89	6	45	244	7.9	5.7	1.6	0.60	0.77	3.5	.	0.3
129	2	2	1	89	6	46	249	7.6	7.2	2.0	0.72	1.08	3.3	0.029	3.3
130	2	2	1	89	6	47	253	8.4	7.9	1.9	0.76	1.13	3.5	0.029	1.4
131	2	2	1	89	6	48	255	9.3	6.6	2.1	0.69	1.33	3.0	0.043	2.7
132	2	2	1	89	6	49	260	7.9	6.7	1.8	1.00	1.12	3.6	0.043	1.2
133	2	2	1	89	6	50	262	7.4	5.2	1.5	0.76	1.27	3.1	0.036	.

134	2	2	1	89	6	51	264	7.8	6.3	1.9	0.81	1.25	3.3	0.087	3.2
135	2	2	1	89	6	52	266	7.2	5.9	1.6	0.89	1.04	4.6	.	1.1
136	2	2	1	89	6	53	268	8.4	7.1	2.0	1.02	1.41	4.1	0.079	1.1
137	2	2	2	89	6	54	250	7.2	6.6	1.6	0.47	1.20	3.6	0.051	1.6
138	2	2	2	89	6	55	252	7.8	6.2	1.6	0.93	1.06	3.1	0.051	2.3
139	2	2	2	89	6	56	254	8.6	6.7	2.0	0.90	1.78	5.6	.	0.2
140	2	2	2	89	6	57	257	7.7	6.7	2.0	0.72	1.29	4.8	0.058	3.4
141	2	2	2	89	6	58	258	5.6	5.1	1.4	0.93	1.66	4.6	.	.
142	2	2	2	89	6	59	259	8.7	7.2	1.9	0.84	2.23	4.1	0.072	3.1
143	2	2	2	89	6	60	261	6.5	2.7	1.6	0.93	0.77	3.0	0.080	3.2
144	2	2	2	89	6	61	263	8.0	6.1	2.0	1.02	1.60	3.7	0.036	2.2
145	2	2	2	89	6	62	265	8.3	6.5	1.9	0.69	1.23	3.9	0.051	.
146	2	2	2	89	6	63	267	8.0	5.6	1.6	0.80	1.14	3.1	.	1.2
147	1	1	1	89	10	1	271	13.5	7.2	2.1	0.94	0.53	2.7	0.120	2.2
148	1	1	1	89	10	2	273	13.7	7.3	2.2	0.92	0.64	2.1	0.120	3.9
149	1	1	1	89	10	3	274	13.5	7.2	1.9	1.06	0.63	2.5	.	.
150	1	1	1	89	10	4	279	14.0	6.5	2.2	1.05	0.60	2.1	.	3.0
151	1	1	1	89	10	5	282	13.8	7.0	1.8	1.12	0.83	2.0	0.051	2.6
152	1	1	1	89	10	6	289	13.5	8.2	2.2	0.93	0.61	2.2	0.032	2.2
153	1	1	2	89	10	7	269	14.6	7.7	2.2	1.03	0.68	2.7	.	3.4
154	1	1	2	89	10	8	272	13.2	6.1	2.0	0.92	0.66	2.7	0.051	4.4
155	1	1	2	89	10	9	278	14.4	6.2	1.9	1.17	0.70	2.5	0.032	2.4
156	1	1	2	89	10	10	280	13.1	7.4	2.2	1.12	0.54	2.1	.	2.6
157	1	1	2	89	10	11	283	14.0	5.3	2.2	1.01	0.59	2.3	.	3.4
158	1	2	1	89	10	12	290	15.1	8.2	2.0	1.10	0.84	2.9	0.025	3.6
159	1	2	1	89	10	13	293	14.1	7.5	2.0	0.73	0.90	2.9	0.032	4.1
160	1	2	1	89	10	14	296	13.4	6.9	1.8	0.78	0.79	2.9	0.019	6.9
161	1	2	1	89	10	15	300	13.8	6.5	2.0	0.91	0.71	3.1	0.019	5.9
162	1	2	1	89	10	16	301	14.2	7.4	2.2	0.83	0.86	2.8	0.032	3.0
163	1	2	1	89	10	17	302	14.7	7.3	1.8	0.96	1.09	4.1	0.013	4.5
164	1	2	1	89	10	18	303	15.0	8.4	2.3	0.80	0.99	3.4	.	6.4
165	1	2	1	89	10	19	304	15.2	8.6	2.3	1.46	0.91	4.0	0.061	7.4
166	1	2	1	89	10	20	306	13.3	8.6	1.8	0.93	1.15	3.5	0.071	5.4
167	1	2	1	89	10	21	307	13.2	5.9	1.9	0.80	0.57	3.3	0.071	3.3
168	1	2	1	89	10	22	308	14.9	8.0	2.1	0.99	1.10	3.6	0.066	3.8
169	1	2	2	89	10	23	291	14.3	8.3	2.5	0.78	0.95	3.9	0.013	4.1
170	1	2	2	89	10	24	292	14.8	8.3	2.1	0.94	0.71	3.4	0.076	3.7
171	1	2	2	89	10	25	294	14.2	6.8	2.0	0.88	0.82	3.1	0.019	5.0
172	1	2	2	89	10	26	295	14.1	7.7	2.0	0.70	0.81	3.4	0.057	2.8
173	1	2	2	89	10	27	297	13.2	8.4	1.9	0.57	0.81	3.2	0.139	3.8
174	1	2	2	89	10	28	298	15.0	9.0	1.9	0.58	0.95	3.8	0.095	5.9
175	1	2	2	89	10	29	299	14.3	8.0	2.0	0.95	0.83	3.8	0.051	4.1
176	1	2	2	89	10	30	305	14.5	6.9	2.0	1.03	0.88	3.2	0.061	6.8
177	2	1	1	89	10	31	227	12.2	7.0	2.0	0.85	0.74	2.2	0.102	2.5
178	2	1	1	89	10	32	230	12.6	8.3	2.1	0.89	0.65	2.0	0.051	3.8
179	2	1	1	89	10	33	228	12.3	6.8	2.2	1.01	0.79	2.1	0.066	2.4
180	2	1	1	89	10	34	232	12.5	7.3	1.9	1.08	0.65	1.6	0.061	3.1
181	2	1	1	89	10	35	234	12.6	6.9	2.2	0.85	0.64	1.7	0.056	2.9
182	2	1	1	89	10	36	240	12.2	6.1	1.9	1.05	0.70	1.5	0.102	3.5
183	2	1	1	89	10	37	241	12.5	7.3	2.1	1.04	0.52	1.5	0.102	3.5
184	2	1	1	89	10	38	242	13.0	5.5	2.1	1.12	0.60	1.4	0.076	5.1
185	2	1	1	89	10	39	243	12.3	7.2	2.1	1.17	0.49	0.9	0.091	4.6
186	2	1	2	89	10	40	231	13.0	5.0	2.0	1.04	0.64	2.3	0.056	4.9
187	2	1	2	89	10	41	235	13.1	6.4	1.9	1.03	0.76	1.9	0.091	3.7
188	2	1	2	89	10	42	236	12.9	7.8	2.0	1.06	0.58	0.8	0.081	2.6
189	2	1	2	89	10	43	238	12.2	6.4	1.8	0.89	0.86	1.6	0.102	5.0
190	2	1	2	89	10	44	239	12.6	5.7	2.2	1.09	0.53	1.3	0.071	4.7
191	2	1	2	89	10	45	244	12.6	6.6	1.8	1.07	0.63	1.7	0.183	3.7
192	2	2	1	89	10	46	249	11.8	7.8	2.2	1.17	0.90	2.4	0.066	3.8
193	2	2	1	89	10	47	253	12.6	9.4	2.3	1.02	0.85	2.2	0.071	3.7
194	2	2	1	89	10	48	255	13.6	7.6	2.0	1.06	1.08	2.8	0.086	4.1
195	2	2	1	89	10	49	260	12.6	7.2	2.0	1.25	0.69	1.5	0.081	3.6
196	2	2	1	89	10	50	262	12.5	6.4	2.0	1.06	0.80	1.9	0.076	2.0
197	2	2	1	89	10	51	264	13.0	6.5	2.1	0.97	0.79	1.9	0.081	3.2
198	2	2	1	89	10	52	266	13.8	7.2	1.9	0.97	0.86	1.3	0.096	2.9
199	2	2	1	89	10	53	268	12.5	7.8	2.1	1.23	0.94	1.8	0.076	5.0
200	2	2	2	89	10	54	250	11.6	9.9	2.1	1.01	0.78	2.2	0.066	4.2
201	2	2	2	89	10	55	252	11.5	6.5	1.8	1.08	0.75	2.4	0.081	3.6
202	2	2	2	89	10	56	254	12.7	5.4	2.0	1.20	0.89	2.7	.	2.6

203	2	2	2	89	10	57	257	12.4	7.5	2.3	1.16	0.96	1.9	0.081	4.9
204	2	2	2	89	10	58	258	12.7	7.4	2.2	1.09	0.94	2.5	0.076	3.0
205	2	2	2	89	10	59	259	11.2	6.5	1.9	1.10	0.71	1.7	0.076	4.3
206	2	2	2	89	10	60	261	13.4	7.1	2.0	1.12	0.75	1.5	0.076	3.2
207	2	2	2	89	10	61	263	12.7	6.7	1.9	1.08	0.81	1.8	0.076	1.9
208	2	2	2	89	10	62	265	13.8	6.8	2.1	1.00	0.98	1.8	0.076	3.3
209	2	2	2	89	10	63	267	13.2	10.0	2.0	1.04	0.77	1.8	.	.

LIVER DATA CODES
(Experiments 1 and 2)

OB = Observation number (1-112).

LO = Location: 1. Bronson.
2. Williston.

Se = Selenium: 1. Treated.
2. Control.

VE = Vitamin E: 1. Treated.
2. Control.

YR = Year (88 and 89).

MT = Month: 6. June.
10. October.

OS = Sample observation number.

COW = Cow number.

Cu = Copper, ppm.

Zn = Zinc, ppm.

Fe = Iron, ppm.

Mn = Manganese, ppm.

Co = Cobalt, ppm.

Mo = Molybdenum, ppm.

Sel = Selenium, ppm.

LIVER DATA

OB	LO	Se	VE	YR	MT	OS	COW	Cu	Zn	Fe	Mn	Co	Mo	Sel
1	1	1	.	88	6	1	42	.	.	.	.	.	.	0.88
2	1	1	.	88	6	2	67	88	94	356	10.1	0.067	0.45	.
3	1	1	.	88	6	3	101	24	115	618	11.8	0.021	2.60	.
4	1	1	.	88	6	4	137	.	.	.	.	.	.	0.81
5	1	2	.	88	6	5	26	.	.	.	.	.	.	0.99
6	1	2	.	88	6	6	332	176	106	267	9.8	0.042	2.99	0.38
7	1	2	.	88	6	7	709	.	.	.	.	.	.	0.74
8	1	2	.	88	6	8	830	170	111	235	11.1	0.093	3.92	1.35
9	1	2	.	88	6	9	860	.	.	.	.	.	.	.
10	2	1	.	88	6	10	279	134	104	223	12.0	0.110	3.68	.
11	2	1	.	88	6	11	716	117	96	184	9.5	0.051	3.62	1.02
12	2	1	.	88	6	12	894	75	89	316	9.8	0.013	5.24	0.59
13	2	1	.	88	6	13	1149	40	99	255	9.7	0.211	6.10	0.80
14	2	2	.	88	6	14	294	36	72	187	11.0	0.116	2.48	.
15	2	2	.	88	6	15	784	280	103	187	10.8	0.170	3.87	.
16	2	2	.	88	6	16	844	306	113	282	10.4	0.104	3.66	0.44
17	2	2	.	88	6	17	897	219	117	288	9.6	0.204	5.40	1.01
18	1	1	.	88	10	1	42	.	.	.	.	.	.	1.79
19	1	1	.	88	10	2	67	102	97	547	8.1	0.014	4.09	.
20	1	1	.	88	10	3	72	53	116	272	9.6	0.136	5.19	0.66
21	1	1	.	88	10	4	137	39	83	64	7.3	0.122	0.37	.
22	1	2	.	88	10	5	387	166	115	73	5.0	0.248	0.27	.
23	1	2	.	88	10	6	709	256	113	268	8.5	0.283	3.16	.
24	1	2	.	88	10	7	830	219	62	38	6.4	0.139	0.02	2.24
25	1	2	.	88	10	8	860	.	.	.	.	.	.	0.68
26	2	1	.	88	10	9	279	300	103	252	13.7	0.185	4.03	1.96
27	2	1	.	88	10	10	303	296	105	250	9.1	0.205	2.42	.
28	2	1	.	88	10	11	490	.	.	.	.	.	.	0.58
29	2	1	.	88	10	12	887	167	97	271	10.7	0.023	4.36	.
30	2	2	.	88	10	13	294	232	160	316	7.0	0.157	4.54	.
31	2	2	.	88	10	14	345	.	.	.	.	.	.	0.29
32	2	2	.	88	10	15	491	.	.	.	.	.	.	1.44
33	2	2	.	88	10	16	874	219	119	273	9.2	0.213	1.81	.
34	2	2	.	88	10	17	897	.	.	.	.	.	.	.
35	1	1	1	89	6	1	53	68	116	1730	24.7	0.287	2.58	1.11
36	1	1	1	89	6	2	105	157	96	492	12.3	0.453	1.11	4.67
37	1	1	1	89	6	3	155	153	211	586	13.5	0.639	1.20	1.39
38	1	1	1	89	6	4	699	106	86	1053	15.8	0.251	0.47	1.63
39	1	1	2	89	6	5	50	126	75	131	8.6	0.541	3.31	1.81
40	1	1	2	89	6	6	101	46	163	859	13.4	0.520	1.68	2.79
41	1	1	2	89	6	7	189	59	75	341	10.6	0.400	0.53	3.37
42	1	1	2	89	6	8	212	62	97	748	16.5	0.520	0.96	1.64
43	1	1	2	89	6	9	222	73	92	1178	17.5	0.402	1.18	1.38
44	1	2	1	89	6	10	151	107	72	605	16.7	0.366	1.05	1.33
45	1	2	1	89	6	11	315	.	.	.	.	.	.	2.36
46	1	2	1	89	6	12	415	201	87	397	12.0	0.245	0.32	1.36
47	1	2	1	89	6	13	548	104	190	544	14.8	0.213	1.02	1.48
48	1	2	1	89	6	14	953	202	149	885	18.5	0.401	0.36	2.97
49	1	2	2	89	6	15	36	.	.	.	.	.	.	1.08
50	1	2	2	89	6	16	256	.	.	.	.	.	.	1.21
51	1	2	2	89	6	17	387	177	107	542	12.5	0.318	4.08	0.93
52	1	2	2	89	6	18	510	326	85	401	14.5	0.423	3.64	2.01
53	1	2	2	89	6	19	901	304	97	396	13.2	0.316	3.36	3.63
54	2	1	1	89	6	20	261	.	.	.	.	.	.	3.15
55	2	1	1	89	6	21	266	192	81	827	18.4	0.270	0.56	.
56	2	1	1	89	6	22	268	203	86	2820	32.7	0.291	1.44	.
57	2	1	1	89	6	23	504	206	86	403	11.4	0.217	1.02	.
58	2	1	2	89	6	24	25	.	.	.	.	.	.	2.46
59	2	1	2	89	6	25	280	.	.	.	.	.	.	1.10
60	2	1	2	89	6	26	297	.	.	.	.	.	.	4.25
61	2	2	1	89	6	27	323	276	96	411	12.2	0.318	0.53	1.67
62	2	2	1	89	6	28	355	88	84	350	12.7	0.330	4.59	2.13
63	2	2	1	89	6	29	522	228	91	1159	18.3	0.346	2.85	1.96
64	2	2	1	89	6	30	550	243	88	607	15.2	0.319	1.69	2.11

65	2	2	1	89	6	31	954	.	.	.	.	.	.	1.83
66	2	2	1	89	6	32	965	229	97	374	11.2	0.278	1.98	0.36
67	2	2	2	89	6	33	125	.	.	.	.	.	.	1.82
68	2	2	2	89	6	34	332	.	.	.	.	.	.	1.03
69	2	2	2	89	6	35	371	.	.	.	.	.	.	1.69
70	2	2	2	89	6	36	744	223	171	665	17.8	0.270	0.96	1.41
71	2	2	2	89	6	37	908	283	81	458	15.9	0.214	1.78	1.47
72	1	1	1	89	10	1	53	.	.	.	.	.	.	1.14
73	1	1	1	89	10	2	105	219	126	245	10.8	0.171	3.28	1.86
74	1	1	1	89	10	3	155	186	96	435	15.6	0.092	1.88	1.53
75	1	1	1	89	10	4	207	123	89	67	7.4	0.031	4.65	.
76	1	1	1	89	10	5	699	214	67	58	11.2	0.072	1.68	0.82
77	1	1	2	89	10	6	50	128	78	311	6.3	0.218	0.71	1.45
78	1	1	2	89	10	7	101	36	117	499	43.2	0.388	0.84	1.11
79	1	1	2	89	10	8	189	78	46	380	46.7	0.223	1.56	1.01
80	1	1	2	89	10	9	212	.	.	.	.	.	.	3.01
81	1	1	2	89	10	10	222	65	58	412	15.4	0.162	1.20	1.05
82	1	2	1	89	10	11	151	164	72	106	7.8	0.101	0.40	1.29
83	1	2	1	89	10	12	315	298	61	91	9.9	0.134	3.01	1.57
84	1	2	1	89	10	13	415	232	66	420	6.7	0.255	0.83	0.92
85	1	2	1	89	10	14	480	173	66	14	10.9	0.106	2.33	.
86	1	2	1	89	10	15	548	.	.	.	.	.	0.81	.
87	1	2	1	89	10	16	904	357	251	33	12.8	0.151	1.70	0.82
88	1	2	2	89	10	17	36	260	72	224	10.9	0.099	1.65	1.68
89	1	2	2	89	10	18	256	135	72	340	8.3	0.131	1.16	0.82
90	1	2	2	89	10	19	387	194	101	453	10.6	0.153	3.33	0.82
91	1	2	2	89	10	20	510	.	.	.	.	.	.	1.29
92	1	2	2	89	10	21	901	215	71	321	53.6	0.235	0.51	1.36
93	2	1	1	89	10	22	261	.	.	.	.	.	.	.
94	2	1	1	89	10	23	266	325	72	270	10.8	0.071	0.18	1.64
95	2	1	1	89	10	24	268	359	94	333	18.8	0.044	1.09	1.39
96	2	1	1	89	10	25	482	319	101	42	18.5	0.095	2.02	0.98
97	2	1	1	89	10	26	856	254	115	246	11.6	0.125	1.95	1.65
98	2	1	2	89	10	27	25	317	92	221	25.2	0.109	2.82	1.57
99	2	1	2	89	10	28	280	264	57	251	9.1	0.046	1.77	1.22
100	2	1	2	89	10	29	297	351	110	305	8.9	0.070	0.09	0.89
101	2	1	2	89	10	30	504	380	82	330	32.9	0.114	0.89	1.29
102	2	1	2	89	10	31	882	387	72	357	9.1	0.071	1.81	1.75
103	2	2	1	89	10	32	323	323	77	170	8.7	0.073	0.70	0.98
104	2	2	1	89	10	33	355	191	81	315	11.6	0.123	2.80	0.68
105	2	2	1	89	10	34	522	.	.	.	.	.	.	0.61
106	2	2	1	89	10	35	550	314	64	229	13.1	0.074	3.64	0.82
107	2	2	1	89	10	36	954	410	80	440	24.4	0.103	3.05	0.68
108	2	2	1	89	10	37	965	332	74	371	59.7	0.211	2.29	0.77
109	2	2	2	89	10	38	125	.	.	.	.	.	.	0.98
110	2	2	2	89	10	39	332	104	57	59	7.8	0.107	5.25	0.62
111	2	2	2	89	10	40	371	153	65	294	40.6	0.111	4.39	1.04
112	2	2	2	89	10	41	908	230	68	423	10.1	0.123	1.23	0.57

MILK DATA CODES
(Experiments 1 and 2)

OB = Observation number (1-246).

LO = Location: 1. Bronson.
2. Williston.

Se = Selenium: 1. Treated.
2. Control.

VE = Vitamin E: 1. Treated.
2. Control.

YR = Year (88 and 89).

MT = Month: 6. June.
10. October.

OS = Sample observation number.

COW = Cow number.

Ca = Calcium, %.

P = Phosphorus, %.

Mg = Magnesium, %.

Na = Sodium, %.

Cu = Copper, ppm.

Zn = Zinc, ppm.

Sel = Selenium, ppm.

MILK DATA

OB	LO	SE	VE	YR	MT	OS	COW	Ca	P	Mg	K	Na	Cu	Zn	Sel
1	1	1	.	88	6	1	12	0.08	0.065	0.15	0.008	0.039	0.15	4.12	0.011
2	1	1	.	88	6	2	42	0.09	0.069	0.24	0.006	0.038	0.14	3.83	0.016
3	1	1	.	88	6	3	67	0.11	0.079	0.20	0.009	0.046	0.22	3.94	0.026
4	1	1	.	88	6	4	72	0.11	0.076	0.31	0.008	0.034	0.25	3.51	0.015
5	1	1	.	88	6	5	101	0.08	0.075	0.22	0.006	0.037	0.15	2.47	0.019
6	1	1	.	88	6	6	110	0.10	0.061	0.20	0.008	0.049	0.17	2.91	0.012
7	1	1	.	88	6	7	122	0.10	0.068	0.21	0.008	0.031	0.26	5.37	0.013
8	1	1	.	88	6	8	137	0.12	0.078	0.22	0.010	0.036	0.24	4.36	0.021
9	1	1	.	88	6	9	383	0.11	0.062	0.19	0.009	0.039	0.21	3.87	.
10	1	1	.	88	6	10	519	0.11	0.073	0.13	0.008	0.040	0.23	3.82	.
11	1	1	.	88	6	11	715	0.10	0.058	0.18	0.009	0.036	0.32	3.33	0.011
12	1	1	.	88	6	12	892	0.13	0.076	0.23	0.011	0.035	0.29	2.93	0.006
13	1	2	.	88	6	13	26	0.07	0.085	0.20	0.005	0.035	0.39	3.29	0.015
14	1	2	.	88	6	14	267	0.02	0.080	0.09	0.001	0.035	0.17	3.77	0.012
15	1	2	.	88	6	15	332	0.14	0.076	0.23	0.012	0.034	3.32	4.12	0.018
16	1	2	.	88	6	16	387	0.12	0.090	0.25	0.011	0.054	0.25	2.79	0.026
17	1	2	.	88	6	17	490	0.11	0.078	0.15	0.009	0.035	0.07	3.91	0.019
18	1	2	.	88	6	18	510	0.12	0.076	0.23	0.009	0.032	0.15	2.57	0.013
19	1	2	.	88	6	19	632	0.11	0.078	0.24	0.008	0.031	0.37	2.88	0.014
20	1	2	.	88	6	20	709	0.11	0.075	0.28	0.008	0.035	0.35	3.08	0.017
21	1	2	.	88	6	21	798	0.13	0.084	0.18	0.010	0.035	0.58	4.46	0.011
22	1	2	.	88	6	22	830	0.12	0.081	0.25	0.010	0.034	0.20	3.74	0.014
23	1	2	.	88	6	23	860	0.11	0.070	0.17	0.009	0.036	0.45	3.30	0.013
24	2	1	.	88	6	24	279	0.10	0.067	0.14	0.006	0.028	0.25	2.33	0.009
25	2	1	.	88	6	25	303	0.13	0.078	0.17	0.010	0.026	0.29	4.07	0.017
26	2	1	.	88	6	26	353	0.10	0.082	0.14	0.008	0.035	0.25	4.34	0.014
27	2	1	.	88	6	27	389	0.11	0.075	0.30	0.008	0.034	0.35	4.06	0.020
28	2	1	.	88	6	28	449	0.10	0.071	0.19	0.007	0.027	0.27	2.67	0.012
29	2	1	.	88	6	29	483	0.10	0.080	0.14	0.006	0.034	0.39	4.85	0.013
30	2	1	.	88	6	30	507	0.11	0.098	0.28	0.011	0.069	0.10	2.85	0.009
31	2	1	.	88	6	31	716	0.11	0.074	0.08	0.008	0.042	0.17	3.67	0.011
32	2	1	.	88	6	32	887	0.11	0.071	0.08	0.009	0.031	0.19	3.53	0.013
33	2	1	.	88	6	33	894	0.10	0.073	0.14	0.007	0.036	0.03	.	0.011
34	2	1	.	88	6	34	1022	0.10	0.066	0.16	0.007	0.033	0.08	4.58	0.007
35	2	2	.	88	6	35	294	0.12	0.071	0.08	0.008	0.034	0.30	2.17	0.021
36	2	2	.	88	6	36	345	0.10	0.065	0.11	0.008	0.054	0.24	3.50	0.011
37	2	2	.	88	6	37	491	0.11	0.088	0.11	0.008	0.044	1.04	.	0.009
38	2	2	.	88	6	38	523	0.11	0.078	0.17	0.008	0.041	0.52	2.67	0.014
39	2	2	.	88	6	39	780	0.05	0.078	0.19	0.004	0.035	0.39	3.31	0.012
40	2	2	.	88	6	40	784	0.12	0.075	0.20	0.009	0.035	0.34	1.82	0.010
41	2	2	.	88	6	41	818	0.12	0.072	0.13	0.008	0.033	0.17	3.64	0.006
42	2	2	.	88	6	42	839	0.12	0.074	0.13	0.007	0.035	0.20	2.74	0.006
43	2	2	.	88	6	43	844	0.11	0.068	0.12	0.006	0.031	0.50	3.46	0.011
44	2	2	.	88	6	44	874	0.12	0.087	0.19	0.008	0.034	0.56	4.15	0.009
45	2	2	.	88	6	45	897	0.12	0.075	0.20	0.009	0.034	0.02	4.23	0.021
46	2	2	.	88	6	46	937	.	.	.	.	.	.	.	.
47	2	2	.	88	6	47	1089	0.13	0.070	0.25	0.009	0.035	0.11	3.22	0.008
48	1	1	.	88	10	1	12	0.12	0.063	0.20	0.013	0.041	0.03	2.82	0.015
49	1	1	.	88	10	2	42	0.10	0.063	0.11	0.008	0.050	0.50	1.40	0.034
50	1	1	.	88	10	3	67	0.11	0.076	0.14	0.010	0.050	0.27	2.79	0.021
51	1	1	.	88	10	4	72	0.13	0.066	0.24	0.011	0.043	0.32	3.10	0.020
52	1	1	.	88	10	5	101	0.12	0.065	0.23	0.009	0.041	0.30	2.89	0.015
53	1	1	.	88	10	6	110	.	.	.	.	.	.	.	.
54	1	1	.	88	10	7	12	.	.	.	.	.	.	.	.
55	1	1	.	88	10	8	137	0.09	0.054	0.04	0.010	.	0.35	1.86	0.065
56	1	1	.	88	10	9	383	.	.	.	.	.	.	.	.
57	1	1	.	88	10	10	715	0.10	0.055	0.15	0.010	0.039	0.22	3.08	0.029
58	1	1	.	88	10	11	892	0.10	0.070	0.17	0.011	0.038	0.15	2.90	0.031
59	1	2	.	88	10	12	26	0.10	0.074	0.24	0.009	0.044	0.07	2.71	0.021
60	1	2	.	88	10	13	267	0.10	0.067	0.20	0.009	0.055	0.20	2.78	0.013
61	1	2	.	88	10	14	332	.	.	.	.	.	.	.	0.012
62	1	2	.	88	10	15	387	0.12	0.079	0.10	0.011	0.055	0.20	1.25	0.018
63	1	2	.	88	10	16	490	0.13	0.058	0.12	0.010	0.057	0.15	1.81	0.011
64	1	2	.	88	10	17	510	0.13	0.063	0.21	0.013	0.042	0.15	2.97	0.009

65	1	2	.	88	10	18	632	0.11	0.063	0.10	0.010	0.045	0.32	2.26	0.019
66	1	2	.	88	10	19	709	0.10	0.066	0.23	0.009	0.036	0.10	2.06	0.014
67	1	2	.	88	10	20	798	0.13	0.079	0.19	0.011	0.014	0.25	2.43	0.010
68	1	2	.	88	10	21	830	0.13	0.065	0.11	0.011	0.047	0.49	1.84	0.012
69	1	2	.	88	10	22	860	0.11	0.067	0.14	0.010	0.044	0.17	2.77	0.026
70	2	1	.	88	10	23	279	0.11	0.064	0.15	0.009	0.045	0.37	3.21	0.021
71	2	1	.	88	10	24	303	0.12	0.074	0.17	0.013	0.042	0.20	3.32	0.019
72	2	1	.	88	10	25	353	.	.	.	.	.	.	.	0.020
73	2	1	.	88	10	26	389	0.13	0.072	0.20	0.010	0.035	0.15	3.33	0.014
74	2	1	.	88	10	27	449	.	.	.	.	.	.	.	.
75	2	1	.	88	10	28	483	0.14	0.075	0.15	0.014	0.062	0.25	0.74	0.016
76	2	1	.	88	10	29	507	0.12	0.079	0.17	0.011	0.038	0.15	2.76	0.012
77	2	1	.	88	10	30	716	0.10	0.073	0.11	0.009	0.038	0.18	1.97	0.013
78	2	1	.	88	10	31	887	0.14	0.077	0.13	0.012	0.037	0.31	3.62	0.017
79	2	1	.	88	10	32	894	.	.	.	.	.	.	.	.
80	2	1	.	88	10	33	1022	0.11	0.050	0.11	0.008	0.054	0.41	2.30	0.020
81	2	2	.	88	10	34	294	0.11	0.061	0.17	0.009	0.038	0.22	1.97	0.020
82	2	2	.	88	10	35	345	0.14	0.071	0.23	0.013	0.048	0.17	2.93	0.015
83	2	2	.	88	10	36	491	0.11	0.063	0.12	0.009	0.049	0.42	2.14	0.017
84	2	2	.	88	10	37	523	0.11	0.063	0.18	0.010	0.048	0.52	3.39	0.007
85	2	2	.	88	10	38	780	0.10	0.063	0.14	0.009	0.071	0.20	3.39	0.015
86	2	2	.	88	10	39	784	.	.	.	.	.	.	.	0.011
87	2	2	.	88	10	40	818	.	.	.	.	.	.	.	.
88	2	2	.	88	10	41	839	0.11	0.063	0.22	0.012	0.044	0.34	2.76	0.012
89	2	2	.	88	10	42	844	0.13	0.060	0.19	0.009	0.038	0.17	2.15	0.012
90	2	2	.	88	10	43	874	0.10	0.068	0.19	0.011	0.040	0.10	2.64	0.013
91	2	2	.	88	10	44	897	0.13	0.067	0.19	0.012	0.040	0.20	3.04	0.014
92	2	2	.	88	10	45	937	0.12	0.059	0.22	0.009	0.040	0.08	2.71	0.016
93	2	2	.	88	10	46	1089	0.11	0.067	0.19	0.009	0.045	0.15	1.74	0.015
94	1	1	1	89	6	1	82	0.10	0.064	0.17	0.008	0.038	0.37	3.84	0.017
95	1	1	1	89	6	2	105	0.11	0.056	0.17	0.006	0.036	0.20	4.26	0.009
96	1	1	1	89	6	3	139	0.12	0.064	0.16	0.010	0.036	0.57	7.16	0.012
97	1	1	1	89	6	4	141	0.12	0.062	0.16	0.010	0.035	0.25	1.87	0.010
98	1	1	1	89	6	5	155	0.11	0.051	0.13	0.008	0.055	0.15	1.26	0.021
99	1	1	1	89	6	6	207	0.17	0.077	0.18	0.009	0.033	0.22	4.56	0.013
100	1	1	1	89	6	7	210	0.11	0.069	0.19	0.009	0.036	0.10	3.03	0.009
101	1	1	1	89	6	8	273	0.12	0.061	0.13	0.007	0.035	0.17	3.10	0.014
102	1	1	1	89	6	9	699	0.12	0.076	0.23	0.010	0.038	0.15	3.57	.
103	1	1	2	89	6	10	50	0.11	0.054	0.20	0.008	0.046	0.80	4.34	0.011
104	1	1	2	89	6	11	78	0.11	0.056	0.14	0.008	0.035	0.51	3.16	0.011
105	1	1	2	89	6	12	101	0.14	0.064	0.20	0.008	0.038	0.22	3.75	0.017
106	1	1	2	89	6	13	189	0.13	0.055	0.10	0.009	0.036	0.70	3.76	0.013
107	1	1	2	89	6	14	212	0.11	0.055	0.20	0.007	0.036	0.60	4.07	0.012
108	1	1	2	89	6	15	222	0.13	0.071	0.16	0.009	0.046	0.25	3.87	0.012
109	1	1	2	89	6	16	301	0.13	0.066	0.12	0.008	0.035	0.50	3.72	0.011
110	1	1	2	89	6	17	378	0.14	0.068	0.23	0.011	0.037	0.65	4.02	0.013
111	1	1	2	89	6	18	527	0.11	0.061	0.10	0.008	0.035	0.35	4.40	0.014
112	1	2	1	89	6	19	151	0.14	0.082	0.20	0.009	0.032	0.23	4.51	0.017
113	1	2	1	89	6	20	228	0.11	0.065	0.17	0.009	0.034	2.17	4.51	0.015
114	1	2	1	89	6	21	315	0.09	0.022	0.15	0.006	0.033	0.10	1.20	0.011
115	1	2	1	89	6	22	409	0.11	0.065	0.14	0.007	0.037	0.40	3.09	0.013
116	1	2	1	89	6	23	415	0.13	0.074	0.19	0.009	0.048	1.15	4.41	0.013
117	1	2	1	89	6	24	480	0.10	0.063	0.23	0.007	0.035	0.17	2.31	0.008
118	1	2	1	89	6	25	548	0.12	0.071	0.18	0.008	0.033	0.20	4.38	0.009
119	1	2	1	89	6	26	632	0.13	0.081	0.14	0.009	0.028	0.10	2.29	0.011
120	1	2	1	89	6	27	798	0.13	0.074	0.14	0.010	0.047	1.65	6.30	0.009
121	1	2	1	89	6	28	904	0.12	0.072	0.18	0.009	0.035	1.88	5.96	0.019
122	1	2	1	89	6	29	953	0.13	0.070	0.16	0.007	0.034	0.15	4.18	0.018
123	1	2	2	89	6	30	36	0.12	0.081	0.21	0.010	0.060	0.32	6.01	0.027
124	1	2	2	89	6	31	103	0.11	0.073	0.17	0.008	0.030	0.17	2.79	0.020
125	1	2	2	89	6	32	256	0.11	0.067	0.17	0.008	0.032	0.34	3.52	0.018
126	1	2	2	89	6	33	293	0.12	0.068	0.22	0.008	0.040	1.76	5.08	0.009
127	1	2	2	89	6	34	369	0.11	0.069	0.17	0.010	0.037	0.27	3.98	0.021
128	1	2	2	89	6	35	387	0.13	0.087	0.20	0.010	0.049	0.52	5.52	0.013
129	1	2	2	89	6	36	510	0.13	0.073	0.16	0.009	0.033	0.28	4.30	0.018
130	1	2	2	89	6	37	544	0.13	0.065	0.16	0.009	0.031	1.24	4.78	0.022
131	1	2	2	89	6	38	901	0.10	0.069	0.19	0.009	0.036	0.93	3.49	0.017
132	2	1	1	89	6	39	85	0.10	0.064	0.11	0.008	0.039	0.50	1.97	0.020
133	2	1	1	89	6	40	266	0.11	0.072	0.19	0.009	0.034	0.54	3.21	0.008

134	2	1	1	89	6	41	268	0.15	0.067	0.19	0.010	0.040	1.92	6.03	0.020
135	2	1	1	89	6	42	291	0.12	0.070	0.19	0.007	0.040	1.77	7.05	0.003
136	2	1	1	89	6	43	307	0.12	0.074	0.23	0.008	0.044	0.23	1.35	0.018
137	2	1	1	89	6	44	482	0.13	0.075	0.18	0.008	0.038	1.35	6.36	0.017
138	2	1	1	89	6	45	502	0.11	0.072	0.25	0.008	0.044	1.45	6.32	0.022
139	2	1	1	89	6	46	504	0.11	0.068	0.14	0.008	0.049	0.25	1.85	0.018
140	2	1	1	89	6	47	516	0.11	0.074	0.14	0.008	0.044	0.42	1.81	0.032
141	2	1	1	89	6	48	856	0.10	0.063	0.08	0.007	0.043	0.69	1.89	.
142	2	1	2	89	6	49	25	0.13	0.066	0.18	0.009	0.043	2.22	1.76	0.019
143	2	1	2	89	6	50	262	0.12	0.074	0.17	0.008	0.040	0.15	2.30	.
144	2	1	2	89	6	51	280	0.10	0.066	0.15	0.008	0.040	0.32	2.27	0.019
145	2	1	2	89	6	52	297	0.09	0.064	0.08	0.007	0.042	0.51	1.38	0.019
146	2	1	2	89	6	53	318	0.11	0.070	0.08	0.008	0.039	0.15	1.98	0.018
147	2	1	2	89	6	54	875	0.11	0.064	0.11	0.009	0.041	0.43	2.02	0.015
148	2	1	2	89	6	55	882	0.13	0.060	0.11	0.009	0.029	0.30	3.75	0.011
149	2	1	2	89	6	56	891	0.12	0.072	0.18	0.008	0.031	1.62	6.29	0.017
150	2	2	1	89	6	57	288	0.13	0.084	0.10	0.008	0.039	0.47	3.46	0.021
151	2	2	1	89	6	58	310	0.11	0.064	0.22	0.007	0.034	0.27	2.35	0.014
152	2	2	1	89	6	59	323	0.11	0.070	0.18	0.008	0.036	0.12	3.39	0.015
153	2	2	1	89	6	60	336	0.11	0.074	0.16	0.009	0.035	0.81	4.11	0.010
154	2	2	1	89	6	61	355	0.11	0.071	0.16	0.007	0.035	0.57	2.91	0.014
155	2	2	1	89	6	62	522	0.13	0.066	0.19	0.009	0.049	1.75	6.76	0.019
156	2	2	1	89	6	63	550	0.12	0.072	0.19	0.009	0.037	1.17	5.80	0.018
157	2	2	1	89	6	64	897	0.08	0.055	0.11	0.007	0.030	0.10	2.54	0.015
158	2	2	1	89	6	65	954	0.12	0.072	0.16	0.009	0.042	0.10	2.55	0.016
159	2	2	1	89	6	66	965	0.09	0.058	0.19	0.007	0.047	0.42	2.27	0.017
160	2	2	2	89	6	67	122	0.13	0.069	0.24	0.008	0.032	1.37	6.12	0.014
161	2	2	2	89	6	68	124	0.12	0.075	0.15	0.008	0.038	0.22	2.77	0.019
162	2	2	2	89	6	69	125	0.13	0.086	0.15	0.009	0.054	0.75	3.00	0.017
163	2	2	2	89	6	70	251	0.12	0.065	0.12	0.008	0.037	0.64	2.75	0.014
164	2	2	2	89	6	71	332	0.09	0.067	0.17	0.008	0.044	0.40	3.20	0.016
165	2	2	2	89	6	72	371	0.10	0.068	0.11	0.007	0.036	1.08	2.94	0.024
166	2	2	2	89	6	73	385	0.12	0.063	0.17	0.009	0.035	0.10	3.06	0.017
167	2	2	2	89	6	74	744	0.12	0.062	0.20	0.008	0.044	0.24	2.84	0.013
168	2	2	2	89	6	75	908	0.11	0.066	0.14	0.009	0.036	1.87	7.32	0.010
169	2	2	2	89	6	76	912	0.11	0.072	0.19	0.008	0.039	0.22	4.67	0.015
170	1	1	1	89	10	1	82	0.12	0.082	0.15	0.010	0.040	0.12	4.08	0.018
171	1	1	1	89	10	2	105	0.08	0.070	0.16	0.007	0.040	0.03	4.48	0.013
172	1	1	1	89	10	3	139	0.10	0.077	0.14	0.010	0.052	0.02	2.84	0.021
173	1	1	1	89	10	4	141	0.10	0.077	0.16	0.009	0.040	0.03	2.79	0.019
174	1	1	1	89	10	5	155	0.10	0.069	0.14	0.009	0.044	0.00	2.17	0.016
175	1	1	1	89	10	6	207	0.11	0.080	0.16	0.008	0.034	0.05	5.00	0.012
176	1	1	1	89	10	7	210	0.11	0.086	0.10	0.009	0.058	0.05	1.24	0.021
177	1	1	1	89	10	8	273	0.07	0.067	0.14	0.006	0.045	0.03	3.11	0.015
178	1	1	1	89	10	9	699	0.09	0.068	0.16	0.010	0.049	0.10	3.34	0.017
179	1	1	2	89	10	10	50	0.07	0.069	0.18	0.008	0.045	0.10	3.24	0.017
180	1	1	2	89	10	11	78	0.08	0.081	0.17	0.007	0.035	0.00	2.45	0.015
181	1	1	2	89	10	12	101	0.12	0.101	0.14	0.009	0.033	0.00	6.08	0.025
182	1	1	2	89	10	13	189	0.12	0.084	0.15	0.011	0.049	0.00	3.76	0.010
183	1	1	2	89	10	14	212	0.09	0.075	0.23	0.007	0.038	0.03	5.33	0.017
184	1	1	2	89	10	15	222	0.07	0.070	0.06	0.010	0.064	0.13	1.32	0.034
185	1	1	2	89	10	16	301	0.09	0.072	0.15	0.008	0.043	0.00	3.08	0.017
186	1	1	2	89	10	17	378	0.10	0.078	0.18	0.008	0.040	0.38	2.25	0.014
187	1	1	2	89	10	18	527	0.08	0.071	0.13	0.008	0.039	0.26	2.95	0.013
188	1	2	1	89	10	19	151	0.09	0.086	0.21	0.009	0.035	0.05	3.58	0.008
189	1	2	1	89	10	20	228	0.07	0.061	0.18	0.009	0.039	0.19	3.44	0.009
190	1	2	1	89	10	21	315	0.08	0.069	0.12	0.007	0.037	0.39	3.69	0.011
191	1	2	1	89	10	22	409	0.06	0.063	0.20	0.007	0.034	0.13	2.28	0.009
192	1	2	1	89	10	23	415	0.07	0.068	0.11	0.009	0.040	0.52	2.49	0.009
193	1	2	1	89	10	24	480	0.05	0.044	0.17	0.006	0.052	0.33	1.42	0.008
194	1	2	1	89	10	25	548	0.06	0.059	0.16	0.007	0.036	0.43	1.36	0.011
195	1	2	1	89	10	26	632	0.07	0.071	0.13	0.008	0.035	0.33	1.79	0.012
196	1	2	1	89	10	27	798	0.09	0.082	0.12	0.009	0.047	0.10	2.93	0.010
197	1	2	1	89	10	28	904	0.06	0.071	0.12	0.007	0.040	0.17	3.24	0.014
198	1	2	1	89	10	29	953	0.07	0.076	0.20	0.007	0.037	0.18	3.42	0.012
199	1	2	2	89	10	30	36	0.07	0.077	0.16	0.009	0.040	0.24	2.32	0.008
200	1	2	2	89	10	31	103	0.06	0.074	0.15	0.009	0.035	0.08	3.00	0.010
201	1	2	2	89	10	32	256	0.07	0.058	0.14	0.008	0.046	0.25	1.76	0.020
202	1	2	2	89	10	33	293	0.08	0.068	0.13	0.008	0.076	0.20	4.44	0.011

203	1	2	2	89	10	34	369	0.07	0.076	0.20	0.010	0.037	0.10	4.06	0.010
204	1	2	2	89	10	35	387	0.09	0.087	0.17	0.010	0.045	0.38	4.30	0.008
205	1	2	2	89	10	36	411	0.09	0.079	0.09	0.009	0.042	0.18	2.89	0.011
206	1	2	2	89	10	37	510	0.06	0.069	0.12	0.007	0.039	0.12	2.96	0.012
207	1	2	2	89	10	38	544	0.08	0.077	0.14	0.008	0.034	0.20	3.02	0.010
208	1	2	2	89	10	39	901	0.07	0.071	0.23	0.009	0.035	0.15	2.61	0.019
209	2	1	1	89	10	40	85	0.08	0.072	0.11	0.008	0.037	0.08	1.88	0.016
210	2	1	1	89	10	41	266	0.04	0.073	0.07	0.005	0.035	0.17	1.74	0.035
211	2	1	1	89	10	42	268	0.07	0.077	0.22	0.008	0.034	0.08	3.19	0.011
212	2	1	1	89	10	43	291	0.07	0.070	0.16	0.007	0.036	0.17	2.36	0.014
213	2	1	1	89	10	44	307	0.08	0.082	0.17	0.009	0.044	0.10	2.52	0.021
214	2	1	1	89	10	45	482	0.08	0.070	0.19	0.008	0.033	0.12	2.94	0.011
215	2	1	1	89	10	46	502	0.08	0.064	0.15	0.008	0.049	0.15	2.36	0.012
216	2	1	1	89	10	47	504	0.07	0.074	0.15	0.008	0.040	0.13	2.82	0.014
217	2	1	1	89	10	48	516	0.08	0.070	0.15	0.009	0.043	0.05	2.67	0.017
218	2	1	1	89	10	49	856	0.08	0.069	0.09	0.008	0.033	0.03	1.21	0.016
219	2	1	2	89	10	50	25	0.09	0.070	0.22	0.010	0.039	0.27	2.31	0.017
220	2	1	2	89	10	51	262	0.10	0.073	0.20	0.008	0.067	0.24	2.63	0.018
221	2	1	2	89	10	52	280	0.07	0.071	0.14	0.008	0.042	0.15	2.26	0.014
222	2	1	2	89	10	53	297	0.07	0.069	0.12	0.008	0.041	0.18	2.10	0.019
223	2	1	2	89	10	54	318	0.08	0.071	0.11	0.009	0.048	0.53	2.48	0.017
224	2	1	2	89	10	55	875	0.08	0.071	0.15	0.008	0.041	0.15	2.01	0.007
225	2	1	2	89	10	56	882	0.07	0.083	0.21	0.008	0.033	0.09	3.62	0.015
226	2	1	2	89	10	57	891	0.09	0.072	0.11	0.009	0.046	0.27	2.46	0.011
227	2	2	1	89	10	58	288	0.10	0.101	0.16	0.009	0.037	0.32	4.45	0.015
228	2	2	1	89	10	59	310	0.10	0.067	0.14	0.009	0.035	0.37	1.72	0.007
229	2	2	1	89	10	60	323	0.08	0.068	0.12	0.008	0.036	0.20	1.92	0.009
230	2	2	1	89	10	61	336	0.09	0.093	0.22	0.011	0.043	0.17	3.85	0.006
231	2	2	1	89	10	62	355	0.07	0.063	0.12	0.007	0.031	0.13	0.78	0.007
232	2	2	1	89	10	63	522	0.07	0.067	0.14	0.008	0.035	0.10	1.51	0.007
233	2	2	1	89	10	64	550	0.08	0.071	0.13	0.008	0.042	0.30	2.94	0.008
234	2	2	1	89	10	65	897	0.02	0.076	0.07	0.004	0.039	0.17	3.18	0.003
235	2	2	1	89	10	66	954	0.07	0.069	0.12	0.008	0.038	0.12	2.29	0.008
236	2	2	1	89	10	67	965	0.06	0.055	0.15	0.008	0.049	0.46	1.99	0.008
237	2	2	2	89	10	68	122	0.07	0.072	0.12	0.007	0.036	0.43	1.60	0.011
238	2	2	2	89	10	69	124	0.06	0.068	0.14	0.006	0.037	0.19	2.01	0.006
239	2	2	2	89	10	70	125	0.07	0.075	0.23	0.009	0.036	0.17	3.03	0.005
240	2	2	2	89	10	71	251	0.10	0.073	0.11	0.009	0.051	0.15	2.97	0.018
241	2	2	2	89	10	72	332	0.08	0.090	0.14	0.009	0.038	0.26	4.25	0.008
242	2	2	2	89	10	73	371	0.07	0.062	0.15	0.007	0.040	0.30	1.07	0.012
243	2	2	2	89	10	74	385	0.08	0.070	0.12	0.008	0.035	0.12	1.48	0.007
244	2	2	2	89	10	75	744	0.08	0.062	0.08	0.008	0.037	0.46	1.41	0.008
245	2	2	2	89	10	76	908	0.08	0.074	0.16	0.010	0.038	0.13	3.13	0.007
246	2	2	2	89	10	77	912	0.08	0.068	0.16	0.009	0.042	0.21	4.35	0.012

SERUM AND MILK COWS DATA CODES
(Experiment 3)

OB = Observation number (1-215).

TRT = Treatment (1-7).

Se = Selenium level:
0.0 mg Se/kg live weight.
1.0 mg Se/kg live weight.
1.5 mg Se/kg live weight.

VE = Vitamin E level:
4.5 mg Se/kg live weight.
9.0 mg Se/kg live weight.

BRE = Breed group: 1-6.

PER = Period:
0 = Pre-treatment.
1 = Parturition.
2 = 1 Month.
3 = 2 Months.

COW = Cow number.

Se1 = Milk Se, ppm.

Se2 = Serum Se, ppm.

VITE = Serum vitamin E, μg α-tocopherol/ml.

COWS DATA

OB	TRT	Se	VE	BRE	PER	COW	Se1	Se2	VITE
1	2	0.0	4.5	1	0	4001	.	0.037	6.4
2	2	0.0	4.5	2	0	4002	.	0.048	4.8
3	3	0.0	9.0	1	0	4004	.	0.054	7.9
4	7	1.5	9.0	2	0	4009	.	0.059	7.6
5	5	1.0	9.0	4	0	4013	.	0.107	9.0
6	5	1.0	9.0	2	0	4015	.	0.021	7.1
7	3	0.0	9.0	4	0	4018	.	0.048	11.1
8	4	1.0	4.5	4	0	4020	.	0.054	8.9
9	4	1.0	4.5	2	0	4023	.	0.037	13.5
10	7	1.5	9.0	3	0	4027	.	0.048	7.8
11	4	1.0	4.5	3	0	4029	.	0.059	3.8
12	1	0.0	0.0	4	0	4031	.	0.043	6.4
13	6	1.5	4.5	4	0	4040	.	0.064	9.0
14	1	0.0	0.0	3	0	4049	.	0.032	4.2
15	2	0.0	4.5	3	0	4052	.	0.048	7.8
16	3	0.0	9.0	3	0	4081	.	0.005	6.3
17	6	1.5	4.5	4	0	4084	.	0.032	8.5
18	7	1.5	9.0	4	0	4085	.	0.043	7.6
19	5	1.0	9.0	3	0	4088	.	0.075	6.3
20	6	1.5	4.5	3	0	4089	.	0.016	8.4
21	5	1.0	9.0	4	0	4090	.	0.021	8.3
22	4	1.0	4.5	4	0	4094	.	0.027	7.0
23	6	1.5	4.5	4	0	4097	.	0.032	4.9
24	2	0.0	4.5	4	0	4098	.	0.016	8.8
25	1	0.0	0.0	3	0	4101	.	0.032	7.4
26	7	1.5	9.0	3	0	4111	.	0.005	5.2
27	7	1.5	9.0	3	0	4113	.	0.027	6.7
28	2	0.0	4.5	4	0	4114	.	0.027	0.8
29	5	1.0	9.0	4	0	4118	.	0.043	6.7
30	3	0.0	9.0	4	0	4119	.	0.011	4.9
31	3	0.0	9.0	5	0	4121	.	0.027	11.1
32	6	1.5	4.5	3	0	4134	.	0.064	5.5
33	5	1.0	9.0	4	0	4135	.	0.134	8.1
34	1	0.0	0.0	3	0	4136	.	0.059	5.4
35	4	1.0	4.5	4	0	4137	.	0.070	5.0
36	7	1.5	9.0	6	0	6003	.	0.011	9.8
37	4	1.0	4.5	6	0	6004	.	0.021	7.0
38	5	1.0	9.0	6	0	6005	.	0.016	4.6
39	1	0.0	0.0	6	0	6009	.	0.021	12.3
40	3	0.0	9.0	6	0	6010	.	0.021	13.0
41	6	1.5	4.5	6	0	6016	.	0.021	9.0
42	2	0.0	4.5	6	0	6019	.	0.027	7.1
43	2	0.0	4.5	6	0	6023	.	0.016	5.8
44	4	1.0	4.5	6	0	6026	.	0.021	8.1
45	6	1.5	4.5	6	0	6028	.	0.032	4.3
46	5	1.0	9.0	6	0	6029	.	0.027	9.6
47	7	1.5	9.0	6	0	6032	.	0.027	5.4
48	3	0.0	9.0	6	0	6033	.	0.059	9.2

49	3	0.0	9.0	6	0	6037	.	0.011	13.1
50	1	0.0	0.0	6	0	6038	.	0.016	12.4
51	4	1.0	4.5	6	0	6041	.	0.021	10.2
52	2	0.0	4.5	6	0	6045	.	0.027	6.8
53	7	1.5	9.0	6	0	6046	.	0.075	8.2
54	1	0.0	0.0	6	0	6055	.	0.054	10.5
55	7	1.5	9.0	6	0	6060	.	0.023	6.2
56	3	0.0	9.0	6	0	6064	.	0.011	5.3
57	5	1.0	9.0	6	0	6070	.	0.006	8.1
58	2	0.0	4.5	1	1	4001	0.069	0.033	6.2
59	2	0.0	4.5	2	1	4002	0.213	0.067	3.6
60	3	0.0	9.0	1	1	4004	0.030	0.055	6.0
61	7	1.5	9.0	2	1	4009	0.038	0.027	6.8
62	5	1.0	9.0	4	1	4013	0.090	0.040	7.4
63	5	1.0	9.0	2	1	4015	0.134	0.047	6.3
64	3	0.0	9.0	4	1	4018	.	0.040	12.3
65	4	1.0	4.5	4	1	4020	0.060	0.033	7.0
66	4	1.0	4.5	2	1	4023	0.053	0.032	11.9
67	7	1.5	9.0	3	1	4027	0.141	0.118	9.6
68	4	1.0	4.5	3	1	4029	0.054	0.094	3.6
69	1	0.0	0.0	4	1	4031	0.053	0.020	3.9
70	6	1.5	4.5	4	1	4040	0.103	0.087	5.0
71	1	0.0	0.0	3	1	4049	0.023	0.079	4.4
72	2	0.0	4.5	3	1	4052	0.022	0.055	7.6
73	3	0.0	9.0	3	1	4081	0.019	0.027	5.4
74	6	1.5	4.5	4	1	4084	0.133	0.033	2.9
75	7	1.5	9.0	4	1	4085	0.025	0.040	1.4
76	5	1.0	9.0	3	1	4088	0.120	0.053	4.5
77	6	1.5	4.5	3	1	4089	0.095	0.033	6.7
78	5	1.0	9.0	4	1	4090	0.061	0.047	3.3
79	4	1.0	4.5	4	1	4094	0.074	0.033	6.2
80	6	1.5	4.5	4	1	4097	0.048	0.053	2.0
81	2	0.0	4.5	4	1	4098	0.040	0.040	4.3
82	1	0.0	0.0	3	1	4101	0.012	0.027	6.2
83	7	1.5	9.0	3	1	4111	0.139	0.080	3.9
84	7	1.5	9.0	3	1	4113	0.029	0.127	4.1
85	2	0.0	4.5	4	1	4114	0.052	0.040	7.5
86	5	1.0	9.0	4	1	4118	0.076	0.047	2.0
87	3	0.0	9.0	4	1	4119	0.013	0.053	2.1
88	3	0.0	9.0	5	1	4121	0.006	0.040	6.3
89	6	1.5	4.5	3	1	4134	0.134	0.074	3.1
90	5	1.0	9.0	4	1	4135	0.020	0.060	3.0
91	1	0.0	0.0	3	1	4136	0.047	0.033	6.3
92	4	1.0	4.5	4	1	4137	0.126	0.100	10.3
93	7	1.5	9.0	6	1	6003	0.047	0.063	7.0
94	4	1.0	4.5	6	1	6004	0.033	0.041	2.1
95	5	1.0	9.0	6	1	6005	0.033	0.023	8.1
96	1	0.0	0.0	6	1	6009	0.047	0.041	3.0
97	3	0.0	9.0	6	1	6010	0.056	0.047	6.3
98	6	1.5	4.5	6	1	6016	0.042	0.055	3.8
99	2	0.0	4.5	6	1	6019	0.044	0.079	4.0
100	2	0.0	4.5	6	1	6023	0.048	0.027	3.4

101	4	1.0	4.5	6	1	6026	0.086	0.092	3.3
102	6	1.5	4.5	6	1	6028	0.076	0.034	2.7
103	5	1.0	9.0	6	1	6029	0.064	0.079	5.4
104	7	1.5	9.0	6	1	6032	0.017	0.051	9.0
105	3	0.0	9.0	6	1	6033	0.031	0.039	4.3
106	3	0.0	9.0	6	1	6037	0.044	0.020	4.5
107	1	0.0	0.0	6	1	6038	0.065	0.046	4.4
108	4	1.0	4.5	6	1	6041	0.033	0.023	11.5
109	2	0.0	4.5	6	1	6045	.	0.023	10.1
110	7	1.5	9.0	6	1	6046	0.089	0.041	2.9
111	1	0.0	0.0	6	1	6055	0.057	0.079	4.5
112	7	1.5	9.0	6	1	6060	0.010	0.060	8.3
113	3	0.0	9.0	6	1	6064	0.041	0.039	3.3
114	5	1.0	9.0	6	1	6070	0.056	0.087	2.5
115	2	0.0	4.5	1	2	4001	0.004	0.027	3.9
116	2	0.0	4.5	2	2	4002	0.010	0.027	3.1
117	3	0.0	9.0	1	2	4004	0.012	0.014	7.6
118	7	1.5	9.0	2	2	4009	0.008	0.053	9.7
119	5	1.0	9.0	4	2	4013	0.008	0.027	4.4
120	5	1.0	9.0	2	2	4015	0.010	0.047	3.7
121	3	0.0	9.0	4	2	4018	0.006	0.034	5.9
122	4	1.0	4.5	4	2	4020	0.009	0.062	4.6
123	4	1.0	4.5	2	2	4023	0.008	0.015	5.7
124	7	1.5	9.0	3	2	4027	0.009	0.038	5.3
125	4	1.0	4.5	3	2	4029	0.025	0.038	3.3
126	1	0.0	0.0	4	2	4031	0.006	0.023	5.3
127	6	1.5	4.5	4	2	4040	0.017	0.046	4.3
128	1	0.0	0.0	3	2	4049	0.005	0.046	2.6
129	2	0.0	4.5	3	2	4052	0.011	0.069	4.6
130	3	0.0	9.0	3	2	4081	0.006	0.021	5.6
131	6	1.5	4.5	4	2	4084	0.020	0.015	3.2
132	7	1.5	9.0	4	2	4085	.	.	.
133	5	1.0	9.0	3	2	4088	0.009	0.038	4.4
134	6	1.5	4.5	3	2	4089	0.012	0.023	6.1
135	5	1.0	9.0	4	2	4090	0.012	0.046	3.7
136	4	1.0	4.5	4	2	4094	0.013	0.023	4.3
137	6	1.5	4.5	4	2	4097	0.017	0.063	5.6
138	2	0.0	4.5	4	2	4098	0.010	0.023	4.4
139	1	0.0	0.0	3	2	4101	0.002	0.023	4.9
140	7	1.5	9.0	3	2	4111	0.008	0.031	3.6
141	7	1.5	9.0	3	2	4113	0.012	0.031	2.5
142	2	0.0	4.5	4	2	4114	0.004	0.015	3.9
143	5	1.0	9.0	4	2	4118	0.008	0.056	3.1
144	3	0.0	9.0	4	2	4119	0.014	0.015	4.0
145	3	0.0	9.0	5	2	4121	0.007	0.055	5.4
146	6	1.5	4.5	3	2	4134	0.009	0.023	1.8
147	5	1.0	9.0	4	2	4135	0.015	0.031	4.8
148	1	0.0	0.0	3	2	4136	0.004	0.063	3.4
149	4	1.0	4.5	4	2	4137	0.012	0.054	3.5
150	7	1.5	9.0	6	2	6003	0.013	0.030	11.6
151	4	1.0	4.5	6	2	6004	0.019	0.038	5.3
152	5	1.0	9.0	6	2	6005	0.042	0.023	5.0

153	1	0.0	0.0	6	2	6009	0.012	0.031	7.3
154	3	0.0	9.0	6	2	6010	0.020	0.034	8.4
155	6	1.5	4.5	6	2	6016	0.045	0.038	4.9
156	2	0.0	4.5	6	2	6019	0.008	0.008	10.2
157	2	0.0	4.5	6	2	6023	0.014	0.047	4.9
158	4	1.0	4.5	6	2	6026	0.016	0.077	7.1
159	6	1.5	4.5	6	2	6028	0.017	0.047	5.5
160	5	1.0	9.0	6	2	6029	0.012	.	.
161	7	1.5	9.0	6	2	6032	.	.	.
162	3	0.0	9.0	6	2	6033	0.021	.	6.3
163	3	0.0	9.0	6	2	6037	0.016	0.054	8.4
164	1	0.0	0.0	6	2	6038	0.023	0.038	15.1
165	7	1.5	9.0	6	2	6060	0.015	0.023	15.1
166	3	0.0	9.0	6	2	6064	0.029	0.015	13.2
167	5	1.0	9.0	6	2	6070	0.021	0.038	7.2
168	2	0.0	4.5	1	3	4001	0.013	0.031	3.6
169	2	0.0	4.5	2	3	4002	0.004	0.063	1.8
170	3	0.0	9.0	1	3	4004	0.009	0.016	5.7
171	5	1.0	9.0	4	3	4013	0.016	0.031	4.2
172	5	1.0	9.0	2	3	4015	0.006	0.024	2.8
173	3	0.0	9.0	4	3	4018	0.004	0.016	6.0
174	4	1.0	4.5	4	3	4020	0.005	0.031	5.0
175	4	1.0	4.5	2	3	4023	0.020	0.031	5.6
176	7	1.5	9.0	3	3	4027	0.008	0.039	6.0
177	1	0.0	0.0	4	3	4031	0.005	0.063	3.3
178	6	1.5	4.5	4	3	4040	0.008	0.039	5.9
179	1	0.0	0.0	3	3	4049	0.003	0.016	2.1
180	2	0.0	4.5	3	3	4052	0.008	0.014	4.3
181	3	0.0	9.0	3	3	4081	0.004	0.016	6.0
182	6	1.5	4.5	4	3	4084	0.010	0.024	4.4
183	7	1.5	9.0	4	3	4085	0.013	0.024	4.8
184	5	1.0	9.0	3	3	4088	0.011	0.031	4.0
185	6	1.5	4.5	3	3	4089	0.006	0.031	6.5
186	5	1.0	9.0	4	3	4090	0.006	0.031	4.1
187	4	1.0	4.5	4	3	4094	0.010	0.055	4.9
188	6	1.5	4.5	4	3	4097	0.013	0.008	10.0
189	2	0.0	4.5	4	3	4098	0.009	0.024	3.6
190	1	0.0	0.0	3	3	4101	0.005	0.063	3.5
191	7	1.5	9.0	3	3	4111	0.006	0.039	3.1
192	7	1.5	9.0	3	3	4113	0.008	0.047	3.9
193	2	0.0	4.5	4	3	4114	0.004	0.021	4.0
194	5	1.0	9.0	4	3	4118	0.006	0.015	8.9
195	3	0.0	9.0	4	3	4119	0.008	0.008	11.2
196	3	0.0	9.0	5	3	4121	0.006	0.028	5.4
197	6	1.5	4.5	3	3	4134	0.009	0.056	3.0
198	5	1.0	9.0	4	3	4135	0.013	0.042	3.8
199	1	0.0	0.0	3	3	4136	0.004	0.056	4.1
200	4	1.0	4.5	4	3	4137	0.012	0.042	3.9
201	7	1.5	9.0	6	3	6003	0.013	0.008	15.8
202	4	1.0	4.5	6	3	6004	0.008	0.030	12.8
203	1	0.0	0.0	6	3	6009	0.013	0.090	12.4
204	3	0.0	9.0	6	3	6010	0.016	0.023	14.2

205	6	1.5	4.5	6	3	6016	0.017	0.060	12.6
206	2	0.0	4.5	6	3	6019	0.010	0.047	11.9
207	2	0.0	4.5	6	3	6023	0.012	0.039	10.8
208	4	1.0	4.5	6	3	6026	0.014	.	6.3
209	6	1.5	4.5	6	3	6028	0.011	0.077	10.9
210	5	1.0	9.0	6	3	6029	0.016	0.055	9.9
211	3	0.0	9.0	6	3	6033	0.024	0.055	13.3
212	3	0.0	9.0	6	3	6037	0.011	0.015	8.9
213	7	1.5	9.0	6	3	6046	.	.	.
214	1	0.0	0.0	6	3	6055	.	.	.
215	5	1.0	9.0	6	3	6070	0.014	0.039	9.8

SERUM CALVES DATA CODES
(Experiment 3)

OB = Observation number (1-158).

TRT = Treatment (1-7).

Se = Selenium level:
0.0 mg Se/kg live weight.
1.0 mg Se/kg live weight.
1.5 mg Se/kg live weight.

VE = Vitamin E level:
4.5 mg Se/kg live weight.
9.0 mg Se/kg live weight.

BRE = Breed group: 1-6.

PER = Period:
1 = Birth.
2 = 1 Month.
3 = 2 Months.

COW = Calf number.

Se3 = Serum Se, ppm.

VITE = Serum vitamin E, μg α-tocopherol/ml.

CALVES DATA

OB	TRT	Se	VE	BRE	PER	CALF	Se3	VITE
1	4	1.0	4.5	3	1	9	0.041	1.2
2	1	0.0	0.0	3	1	10	0.027	1.3
3	3	0.0	9.0	2	1	11	0.027	2.5
4	7	1.5	9.0	5	1	12	0.047	1.4
5	3	0.0	9.0	3	1	13	0.041	0.6
6	5	1.0	9.0	2	1	17	0.034	0.8
7	1	0.0	0.0	4	1	18	0.027	0.6
8	2	0.0	4.5	4	1	19	0.020	1.8
9	7	1.5	9.0	2	1	20	0.027	1.0
10	3	0.0	9.0	4	1	21	0.020	2.1
11	2	0.0	4.5	2	1	24	0.020	0.4
12	5	1.0	9.0	2	1	25	0.041	0.5
13	6	1.5	4.5	3	1	26	0.034	1.4
14	6	1.5	4.5	5	1	27	0.061	3.9
15	2	0.0	4.5	3	1	28	0.041	0.4
16	5	1.0	9.0	4	1	29	0.027	2.5
17	4	1.0	4.5	5	1	33	0.047	0.3
18	6	1.5	4.5	3	1	34	0.047	0.3
19	2	0.0	4.5	5	1	35	0.041	0.3
20	7	1.5	9.0	4	1	36	0.054	0.6
21	1	0.0	0.0	4	1	37	0.014	0.2
22	4	1.0	4.5	4	1	40	0.061	0.9
23	6	1.5	4.5	4	1	41	0.081	0.4
24	3	0.0	9.0	3	1	42	0.041	4.4
25	1	0.0	0.0	4	1	45	0.034	0.5
26	4	1.0	4.5	3	1	50	0.041	0.2
27	2	0.0	4.5	4	1	51	0.020	0.3
28	5	1.0	9.0	4	1	60	0.027	0.4
29	4	1.0	4.5	6	1	76	0.047	0.2
30	5	1.0	9.0	5	1	77	0.047	0.7
31	7	1.5	9.0	4	1	83	0.034	0.6
32	4	1.0	4.5	6	1	86	0.061	0.7
33	3	0.0	9.0	5	1	104	0.014	0.3
34	3	0.0	9.0	4	1	105	0.034	0.9
35	5	1.0	9.0	4	1	106	0.041	0.7
36	1	0.0	0.0	4	1	107	0.020	1.7
37	7	1.5	9.0	6	1	116	0.027	0.5
38	6	1.5	4.5	2	1	125	0.047	0.7
39	6	1.5	4.5	4	1	132	0.041	0.2
40	2	0.0	4.5	5	1	134	0.054	0.6
41	1	0.0	0.0	5	1	135	0.056	1.4
42	7	1.5	9.0	1	1	138	0.047	1.0
43	4	1.0	4.5	3	1	143	0.079	0.9
44	7	1.5	9.0	4	1	146	0.047	0.4
45	2	0.0	4.5	5	1	148	0.039	0.5
46	3	0.0	9.0	5	1	152	0.039	0.2
47	6	1.5	4.5	5	1	153	0.055	0.4
48	5	1.0	9.0	6	1	157	0.047	0.4

49	3	0.0	9.0	4	1	158	0.021	0.3
50	5	1.0	9.0	6	1	161	0.063	0.7
51	1	0.0	0.0	4	1	166	0.023	0.8
52	3	0.0	9.0	5	1	173	0.128	1.0
53	7	1.5	9.0	6	1	179	0.030	1.2
54	5	1.0	9.0	6	1	180	0.030	0.2
55	4	1.0	4.5	6	1	183	0.023	0.2
56	2	0.0	4.5	4	1	184	0.015	1.2
57	7	1.5	9.0	6	1	187	0.023	1.7
58	4	1.0	4.5	3	2	9	0.077	1.6
59	1	0.0	0.0	3	2	10	0.062	1.7
60	3	0.0	9.0	2	2	11	0.085	1.3
61	7	1.5	9.0	5	2	12	0.054	1.9
62	3	0.0	9.0	3	2	13	0.038	2.8
63	5	1.0	9.0	2	2	17	0.046	1.7
64	1	0.0	0.0	4	2	18	0.031	1.4
65	2	0.0	4.5	4	2	19	0.031	1.4
66	7	1.5	9.0	2	2	20	0.031	1.6
67	3	0.0	9.0	4	2	21	0.038	2.1
68	2	0.0	4.5	2	2	24	0.087	0.7
69	5	1.0	9.0	2	2	25	0.071	2.1
70	6	1.5	4.5	3	2	26	0.062	3.4
71	6	1.5	4.5	5	2	27	0.071	2.0
72	2	0.0	4.5	3	2	28	0.031	2.1
73	5	1.0	9.0	4	2	29	0.031	3.0
74	4	1.0	4.5	5	2	33	0.031	1.2
75	6	1.5	4.5	3	2	34	0.008	1.0
76	2	0.0	4.5	5	2	35	0.031	2.3
77	7	1.5	9.0	4	2	36	0.008	2.1
78	1	0.0	0.0	4	2	37	0.014	1.4
79	4	1.0	4.5	4	2	40	0.021	1.2
80	6	1.5	4.5	4	2	41	0.038	3.9
81	3	0.0	9.0	3	2	42	0.015	1.4
82	1	0.0	0.0	4	2	45	0.023	1.4
83	4	1.0	4.5	3	2	50	0.038	2.2
84	2	0.0	4.5	4	2	51	0.023	2.2
85	5	1.0	9.0	4	2	60	0.039	1.8
86	4	1.0	4.5	6	2	76	0.031	1.9
87	5	1.0	9.0	5	2	77	0.024	0.7
88	7	1.5	9.0	4	2	83	0.031	1.2
89	4	1.0	4.5	6	2	86	0.039	1.4
90	3	0.0	9.0	5	2	104	0.039	0.8
91	3	0.0	9.0	4	2	105	0.157	1.4
92	5	1.0	9.0	4	2	106	0.039	0.8
93	1	0.0	0.0	4	2	107	0.039	2.7
94	6	1.5	4.5	2	2	125	0.055	1.5
95	6	1.5	4.5	4	2	132	0.031	1.4
96	2	0.0	4.5	5	2	134	0.031	0.4
97	7	1.5	9.0	1	2	138	0.055	0.8
98	4	1.0	4.5	3	2	143	0.039	1.0
99	7	1.5	9.0	4	2	146	0.039	1.5
100	2	0.0	4.5	5	2	148	0.032	1.2

101	3	0.0	9.0	5	2	152	0.023	1.1
102	6	1.5	4.5	5	2	153	0.023	0.6
103	5	1.0	9.0	6	2	157	0.023	0.7
104	3	0.0	9.0	4	2	158	0.000	0.5
105	5	1.0	9.0	6	2	161	0.015	0.2
106	1	0.0	0.0	4	2	166	0.015	5.1
107	3	0.0	9.0	5	2	173	0.105	1.9
108	7	1.5	9.0	6	2	179	0.008	0.5
109	5	1.0	9.0	6	2	180	0.000	0.2
110	7	1.5	9.0	6	2	187	.	.
111	4	1.0	4.5	3	3	9	0.035	1.3
112	1	0.0	0.0	3	3	10	0.028	3.8
113	3	0.0	9.0	2	3	11	0.035	4.6
114	7	1.5	9.0	5	3	12	0.035	3.0
115	3	0.0	9.0	3	3	13	0.042	2.1
116	5	1.0	9.0	2	3	17	0.035	2.6
117	1	0.0	0.0	4	3	18	0.064	2.4
118	2	0.0	4.5	4	3	19	0.049	2.1
119	7	1.5	9.0	2	3	20	0.028	3.2
120	3	0.0	9.0	4	3	21	0.021	3.4
121	2	0.0	4.5	2	3	24	0.014	1.3
122	5	1.0	9.0	2	3	25	0.028	2.4
123	6	1.5	4.5	3	3	26	0.028	1.9
124	6	1.5	4.5	5	3	27	0.021	1.7
125	2	0.0	4.5	3	3	28	0.028	1.7
126	5	1.0	9.0	4	3	29	0.049	2.4
127	4	1.0	4.5	5	3	33	0.028	2.0
128	6	1.5	4.5	3	3	34	0.021	1.3
129	2	0.0	4.5	5	3	35	0.021	3.4
130	7	1.5	9.0	4	3	36	0.042	1.9
131	1	0.0	0.0	4	3	37	0.021	1.6
132	4	1.0	4.5	4	3	40	0.035	2.1
133	6	1.5	4.5	4	3	41	0.028	3.4
134	3	0.0	9.0	3	3	42	0.035	2.0
135	1	0.0	0.0	4	3	45	0.007	2.8
136	4	1.0	4.5	3	3	50	0.035	2.0
137	2	0.0	4.5	4	3	51	0.014	1.4
138	5	1.0	9.0	4	3	60	0.134	1.0
139	4	1.0	4.5	6	3	76	0.042	1.3
140	5	1.0	9.0	5	3	77	0.007	0.8
141	7	1.5	9.0	4	3	83	0.014	0.8
142	4	1.0	4.5	6	3	86	0.045	2.9
143	3	0.0	9.0	5	3	104	0.008	4.0
144	3	0.0	9.0	4	3	105	0.015	3.6
145	5	1.0	9.0	4	3	106	0.008	1.4
146	1	0.0	0.0	4	3	107	0.038	1.8
147	7	1.5	9.0	6	3	116	.	.
148	6	1.5	4.5	2	3	125	0.015	3.5
149	6	1.5	4.5	4	3	132	0.039	4.6
150	2	0.0	4.5	5	3	134	0.032	4.6
151	1	0.0	0.0	5	3	135	.	.
152	7	1.5	9.0	4	3	146	.	3.0

153	2	0.0	4.5	5	3	148	0.047	10.2
154	3	0.0	9.0	5	3	152	0.024	5.3
155	6	1.5	4.5	5	3	153	0.032	1.1
156	5	1.0	9.0	6	3	157	0.032	3.3
157	3	0.0	9.0	5	3	158	0.032	5.7
158	5	1.0	9.0	6	3	161	0.032	0.9

SERUM AND MILK EWES DATA CODES
(Experiment 4)

OB = Observation number (1-60).

TRT = Treatment (1-7).

Se = Selenium level:
0.0 mg Se/kg live weight.
1.0 mg Se/kg live weight.
1.5 mg Se/kg live weight.

VE = Vitamin E level:
4.5 mg Se/kg live weight.
9.0 mg Se/kg live weight.

PER = Period:
0 = Pre-treatment.
1 = Parturition.
2 = 1 Month.
3 = 2 Months.

EWE = Ewe number.
Se1 = Milk Se, ppm.
Se2 = Serum Se, ppm.
VITE = Serum vitamin E, μg α-tocopherol/ml.

EWES DATA

OB	TRT	Se	VE	PER	EWE	Se1	Se2	VITE
1	5	1.0	9.0	0	714	.	0.028	4.8
2	6	1.5	4.5	0	718	.	0.028	2.9
3	2	0.0	4.5	0	721	.	0.028	3.8
4	7	1.5	9.0	0	724	.	0.023	1.9
5	5	1.0	9.0	0	727	.	0.062	6.3
6	7	1.5	9.0	0	737	.	0.045	2.5
7	3	0.0	9.0	0	740	.	0.023	6.3
8	7	1.5	9.0	0	901	.	0.028	6.0
9	3	0.0	9.0	0	907	.	0.045	4.4
10	4	1.0	4.5	0	913	.	0.023	7.1
11	6	1.5	4.5	0	915	.	0.017	3.9
12	1	0.0	0.0	0	919	.	0.062	7.0
13	1	0.0	0.0	0	923	.	0.049	1.7
14	2	0.0	4.5	0	925	.	0.085	2.2
15	1	0.0	0.0	0	927	.	0.034	5.8
16	5	1.0	9.0	1	714	0.047	0.074	2.5
17	6	1.5	4.5	1	718	0.237	0.017	4.6
18	2	0.0	4.5	1	721	0.061	0.079	2.9
19	7	1.5	9.0	1	724	0.128	0.045	3.3
20	5	1.0	9.0	1	727	0.179	0.085	4.7
21	7	1.5	9.0	1	737	0.181	0.113	4.1
22	3	0.0	9.0	1	740	0.002	0.079	4.2
23	7	1.5	9.0	1	901	0.215	0.192	3.5
24	3	0.0	9.0	1	907	0.053	0.028	3.4
25	4	1.0	4.5	1	913	0.246	0.158	4.6
26	6	1.5	4.5	1	915	0.204	0.147	3.8
27	1	0.0	0.0	1	919	0.050	0.142	3.6
28	1	0.0	0.0	1	923	0.031	0.068	2.9
29	2	0.0	4.5	1	925	0.023	0.079	3.5
30	1	0.0	0.0	1	927	0.060	0.091	4.4
31	5	1.0	9.0	2	714	0.027	0.059	1.7
32	6	1.5	4.5	2	718	0.032	0.092	2.6
33	2	0.0	4.5	2	721	0.017	0.092	2.8
34	7	1.5	9.0	2	724	0.026	0.066	1.9
35	5	1.0	9.0	2	727	0.028	0.086	2.9
36	7	1.5	9.0	2	737	0.021	0.099	3.2
37	3	0.0	9.0	2	740	0.014	0.073	3.1
38	7	1.5	9.0	2	901	0.035	0.086	2.2
39	3	0.0	9.0	2	907	0.017	0.059	1.5
40	4	1.0	4.5	2	913	0.019	0.099	1.7
41	6	1.5	4.5	2	915	0.023	0.119	1.5
42	1	0.0	0.0	2	919	0.017	0.079	2.0
43	1	0.0	0.0	2	923	0.027	0.086	1.3
44	2	0.0	4.5	2	925	0.017	0.059	1.1
45	1	0.0	0.0	2	927	0.013	0.073	1.8
46	5	1.0	9.0	3	714	0.020	0.073	2.2
47	6	1.5	4.5	3	718	0.024	0.066	1.6
48	2	0.0	4.5	3	721	0.015	0.079	1.8

49	7	1.5	9.0	3	724	0.017	0.073	1.3
50	5	1.0	9.0	3	727	0.026	0.079	1.4
51	7	1.5	9.0	3	737	0.013	0.066	.
52	3	0.0	9.0	3	740	0.024	0.073	1.5
53	7	1.5	9.0	3	901	0.022	0.086	1.7
54	3	0.0	9.0	3	907	0.019	0.053	2.7
55	4	1.0	4.5	3	913	0.021	0.046	1.7
56	6	1.5	4.5	3	915	0.015	0.079	4.4
57	1	0.0	0.0	3	919	0.029	0.026	2.2
58	1	0.0	0.0	3	923	0.020	0.073	1.5
59	2	0.0	4.5	3	925	0.015	0.059	1.2
60	1	0.0	0.0	3	927	0.020	0.053	2.1

SERUM LAMBS DATA CODES
(Experiment 4)

OB = Observation number (1-57).

TRT = Treatment (1-7).

Se = Selenium level:
0.0 mg Se/kg live weight.
1.0 mg Se/kg live weight.
1.5 mg Se/kg live weight.

VE = Vitamin E level:
4.5 mg Se/kg live weight.
9.0 mg Se/kg live weight.

PER = Period:
1 = Birth.
2 = 1 Month.
3 = 2 Months.

Lamb = Ewe number.
Se3 = Serum Se, ppm.
VITE = Serum vitamin E, μg α-tocopherol/ml.

LAMBS DATA

OB	SEX	TRT	Se	VE	PER	Lamb	Se3	VITE
1	1	4	1.0	4.5	1	105	0.068	2.7
2	1	4	1.0	4.5	1	106	0.034	1.1
3	1	1	0.0	0.0	1	107	0.079	1.0
4	2	3	0.0	9.0	1	108	0.243	4.6
5	2	7	1.5	9.0	1	110	0.045	1.9
6	1	7	1.5	9.0	1	111	0.085	1.0
7	1	7	1.5	9.0	1	112	0.040	7.0
8	1	5	1.0	9.0	1	113	0.068	2.7
9	2	1	0.0	0.0	1	114	0.040	1.0
10	1	1	0.0	0.0	1	115	0.079	1.6
11	1	2	0.0	4.5	1	116	0.023	1.2
12	1	7	1.5	9.0	1	117	0.040	5.4
13	2	6	1.5	4.5	1	118	0.091	0.2
14	2	6	1.5	4.5	1	119	0.015	1.2
15	1	2	0.0	4.5	1	120	0.023	2.7
16	2	5	1.0	9.0	1	121	0.071	4.4
17	2	3	0.0	9.0	1	122	0.028	6.6
18	1	3	0.0	9.0	1	123	0.106	5.2
19	2	6	1.5	4.5	1	124	0.085	0.7
20	1	4	1.0	4.5	2	105	0.119	1.6
21	1	4	1.0	4.5	2	106	0.099	0.8
22	1	1	0.0	0.0	2	107	0.086	1.5
23	2	3	0.0	9.0	2	108	0.059	0.6
24	2	7	1.5	9.0	2	110	0.066	0.9
25	1	7	1.5	9.0	2	111	0.099	1.2
26	1	7	1.5	9.0	2	112	0.073	0.7
27	1	5	1.0	9.0	2	113	0.079	1.4
28	2	1	0.0	0.0	2	114	0.059	1.3
29	1	1	0.0	0.0	2	115	0.066	1.5
30	1	2	0.0	4.5	2	116	0.086	1.1
31	1	7	1.5	9.0	2	117	0.073	1.3
32	2	6	1.5	4.5	2	118	0.066	1.4
33	2	6	1.5	4.5	2	119	0.066	1.3
34	1	2	0.0	4.5	2	120	0.099	1.8
35	2	5	1.0	9.0	2	121	0.059	1.9
36	2	3	0.0	9.0	2	122	0.040	1.7
37	1	3	0.0	9.0	2	123	0.033	1.3
38	2	6	1.5	4.5	2	124	0.040	0.6
39	1	4	1.0	4.5	3	105	0.053	0.9
40	1	4	1.0	4.5	3	106	0.053	0.8
41	1	1	0.0	0.0	3	107	0.047	1.2
42	2	3	0.0	9.0	3	108	0.113	0.7
43	2	7	1.5	9.0	3	110	0.060	0.7
44	1	7	1.5	9.0	3	111	0.227	0.4
45	1	7	1.5	9.0	3	112	0.080	0.6
46	1	5	1.0	9.0	3	113	0.080	0.9
47	2	1	0.0	0.0	3	114	0.053	1.2
48	1	1	0.0	0.0	3	115	0.100	0.6

49	1	2	0.0	4.5	3	116	0.047	1.4
50	1	7	1.5	9.0	3	117	0.127	0.7
51	2	6	1.5	4.5	3	118	0.060	0.5
52	2	6	1.5	4.5	3	119	0.133	0.6
53	1	2	0.0	4.5	3	120	0.140	1.4
54	2	5	1.0	9.0	3	121	0.080	3.0
55	2	3	0.0	9.0	3	122	0.027	1.6
56	1	3	0.0	9.0	3	123	0.027	1.3
57	2	6	1.5	4.5	3	124	0.053	1.0

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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